Maintenance Information for:

Fiber Optic Links (ESCON, FICON, Coupling Links, and Open System Adapters)

SY27-2597-12

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SY27-2597-12

Note!

Before using this information and the products it supports, be sure to read the general information under “Safety and Environmental Notices” on page vii and Appendix F, “Notices,” on page F-1.

Thirteenth Edition (September 2005)

This edition replaces SY27-2597-10, SY27-2597-10a, SY27-2597-10b, and SY27-2597-11. A technical change to the text or illustration is indicated by a vertical line to the left of the change. This edition, SY27-2597-12, applies to Maintenance Information for: Fiber Optic Links (ESCON, FICON, Coupling Links and Open System Adapters).

There may be a newer version of this document in PDF format available on Resource Link™. Go to *http://www.ibm.com/servers/resourcelink* and click on **Library** on the navigation bar. A newer version is indicated by a lower-case, alphabetic letter following the form number suffix (for example: 00a, 00b, 01a, 01b).

Contents

Safety and Environmental Notices

Safety Notices

Safety notices may be printed throughout this guide. **DANGER** notices warn you of conditions or procedures that can result in death or severe personal injury. **CAUTION** notices warn you of conditions or procedures that can cause personal injury that is neither lethal nor extremely hazardous. **Attention** notices warn you of conditions or procedures that can cause damage to machines, equipment, or programs.

World Trade Safety Information

Several countries require the safety information contained in product publications to be presented in their national languages. If this requirement applies to your country, a safety information booklet is included in the publications package shipped with the product. The booklet contains the safety information in your national language with references to the US English source. Before using a US English publication to install, operate, or service this IBM product, you must first become familiar with the related safety information in the booklet. You should also refer to the booklet any time you do not clearly understand any safety information in the US English publications.

Laser Safety Information

All System z9 and zSeries models can use I/O cards such as PCI adapters, ESCON, FICON, Open Systems Adapter (OSA), InterSystem Coupling-3 (ISC-3), or other I/O features which are fiber optic based and utilize lasers or LEDs.

Laser Compliance

All lasers are certified in the U.S. to conform to the requirements of DHHS 21 CFR Subchapter J for class 1 laser products. Outside the U.S., they are certified to be in compliance with IEC 60825 as a class 1 laser product. Consult the label on each part for laser certification numbers and approval information.

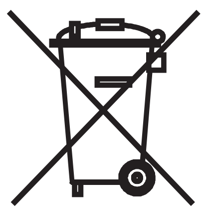
CAUTION:
Data processing environments can contain equipment transmitting on system links with laser modules that operate at greater than Class 1 power levels. For this reason, never look into the end of an optical fiber cable or open receptacle. (C027)

CAUTION:
This product contains a Class 1M laser. Do not view directly with optical instruments. (C028)

Environmental Notices

Product Recycling and Disposal

This unit must be recycled or discarded according to applicable local and national regulations. IBM encourages owners of information technology (IT) equipment to responsibly recycle their equipment when it is no longer needed. IBM offers a variety of product return programs and services in several countries to assist equipment owners in recycling their IT products. Information on IBM product recycling offerings can be found on IBM's Internet site at *http://www.ibm.com/ibm/environment/products/prp.shtml*.



Notice: This mark applies only to countries within the European Union (EU) and Norway.

Appliances are labeled in accordance with European Directive 2002/96/EC concerning waste electrical and electronic equipment (WEEE). The Directive determines the framework for the return and recycling of used appliances as applicable throughout the European Union. This label is applied to various products to indicate that the product is not to be thrown away, but rather reclaimed upon end of life per this Directive.

In accordance with the European WEEE Directive, electrical and electronic equipment (EEE) is to be collected separately and to be reused, recycled, or recovered at end of life. Users of EEE with the WEEE marking per Annex IV of the WEEE Directive, as shown above, must not dispose of end of life EEE as unsorted municipal waste, but use the collection framework available to customers for the return, recycling, and recovery of WEEE. Customer participation is important to minimize any potential effects of EEE on the environment and human health due to the potential presence of hazardous substances in EEE. For proper collection and treatment, contact your local IBM representative.

注意: このマークは EU 諸国およびノルウェーにおいてのみ適用されます。

この機器には、EU 諸国に対する廃電気電子機器指令 2002/96/EC(WEEE) のラベルが貼られています。この指令は、EU 諸国に適用する使用済み機器の回収とリサイクルの骨子を定めています。このラベルは、使用済みになった時に指令に従って適正な処理をする必要があることを知らせるために種々の製品に貼られています。

Remarque : Cette marque s'applique uniquement aux pays de l'Union Européenne et à la Norvège.

L'étiquette du système respecte la Directive européenne 2002/96/EC en matière de Déchets des Equipements Electriques et Electroniques (DEEE), qui détermine les dispositions de retour et de recyclage applicables aux systèmes utilisés à travers l'Union européenne. Conformément à la directive, ladite étiquette précise que le produit sur lequel elle est apposée ne doit pas être jeté mais être récupéré en fin de vie.

Refrigeration

These systems contain a modular refrigeration unit with R-134A refrigerant and a polyol ester oil. This refrigerant must not be released or vented to the atmosphere. Skin contact with refrigerant may cause frostbite. Wear appropriate eye and skin protection. Modular refrigeration units are sealed and must not be opened or maintained.

Battery Return Program

This product may contain sealed lead acid, nickel cadmium, nickel metal hydride, lithium, or lithium ion battery(s). Consult your user manual or service manual for specific battery information. The battery must be recycled or disposed of properly. Recycling facilities may not be available in your area. For information on disposal of batteries outside the United States, go to *http://www.ibm.com/ibm/environment/products/batteryrecycle.shtml* or contact your local waste disposal facility.

In the United States, IBM has established a return process for reuse, recycling, or proper disposal of used IBM sealed lead acid, nickel cadmium, nickel metal hydride, and other battery packs from IBM Equipment. For information on proper disposal of these batteries, contact IBM at 1-800-426-4333. Please have the IBM part number listed on the battery available prior to your call.

In Taiwan, the following applies:

Please recycle batteries 廢電池請回收

IBM Cryptographic Coprocessor Card Return Program

This machine may contain an optional feature, the cryptographic coprocessor card, which includes a polyurethane material that contains mercury. Please follow Local Ordinances or regulations for disposal of this card. IBM has established a return program for certain IBM Cryptographic Coprocessor Cards. More information can be found at *http://www.ibm.com/ibm/environment/products/prp.shtml*.

برنامج ارجاع كرت IBM Cryptographic Coprocessor

هذه الماكينة قد تحتوي على خاصية اختيارية، وهى كارت Cryptographic Coprocessor
والتي تحتوي على مادة بولييوريثين التي تحتوي على الزئبق
رجاء اتباع القوانين أو التعليمات المحلية للتخلص من هذا الكارت .
قامت شركة IBM باعداد برنامج لارجاع بعض كروت IBM Cryptographic Coprocessor

لمزيد من المعلومات، رجاء زيارة الموقع
http://www.ibm.com/ibm/environment/products/prp.shtml

Cable Warning

WARNING: Handling the cord on this product or cords associated with accessories sold with this product, will expose you to lead, a chemical known to the State of California to cause cancer, and birth defects or other reproductive harm. ***Wash hands after handling.***

About This Publication

This publication provides problem determination, verification, and repair procedures for IBM® fiber optic channel links. This designation includes IBM coupling facility channels, IBM Enterprise Systems Connection (ESCON™) links, Fiber Channel Connection (FICON™) and fiber optic interfaces for Open System Adapters (OSA), including Fiber Distributed Data Interface (FDDI), Asynchronous Transfer Mode (ATM), and Gigabit Ethernet (GEN) for zSeries™ and System z9™.

Although this publication covers fiber optic cable types and environments in general. The specific information includes only what is supported for IBM fiber optic channel links. Although the ANSI Fibre Channel Standard does not include the use of long wavelength (1300 nm) lasers on multimode fiber, z/Series will support this combination as specified in *Fiber Channel Connection for S/390® I/O Interface Physical Layer*, SA24-7172.

Note: This publication, with the publication *Planning for Fiber Optic Channel Links*, GA23-0367, replaces the publication *IBM 3044 Fiber-Optic Channel Extender Link Models C02 and D02: Fiber-Optic Cable Planning, Installation, and Maintenance Guide*, GC22-7130, and makes it obsolete.

Who Should Use This Publication

This publication should be used by service representatives who need to perform problem determination on a fiber optic link.

What Is Included in This Publication

This publication contains five chapters and five appendixes:

- **Chapter 1, "Introduction to Fiber Optic Links",** provides a brief introduction to fiber optic information transfer and optical link components, and shows a typical fiber optic channel link configuration.
- **Chapter 2, "Service Strategy and Maintenance Activities,"** contains a summary of the service tasks, strategy, and activities associated with fiber optic channel links. It also shows typical link configurations, describes some common link failures, and shows how to determine the direction of light propagation in an IBM jumper cable and in a fiber optic channel link. This chapter also provides a summary for the link verification procedures performed using the MAPs in Chapter 3.
- **Chapter 3, "Problem Determination Procedures,"** provides information that can be used to isolate link failures between two devices. It is divided into two sections: the first section provides the maintenance analysis procedures (MAPs) used to perform step-by-step problem determination; the second section provides information for using the "fast-path" method.
- **Chapter 4, "Jumper Cable Handling and Installation Summary,"** provides guidance for handling fiber optic jumper cables and summarizes the tasks associated with their installation.
- **Chapter 5, "Documentation,"** summarizes the information used to document link installations. It provides instructions and a sample work sheet for recording link specifications and physical characteristics.
- **Appendix A, "Specifications,"** lists the specifications and optical properties required for components used in a fiber optic channel link.

- **Appendix B, “Tools, Test Equipment, and Parts,”** lists the tools, test equipment, and parts used to perform problem determination and testing for fiber optic channel links.
- **Appendix C, “Measuring Device Transmit and Receive Levels,”** contains procedures on how to determine if the transmit and receive signals are within specification. Although these procedures are also contained in the maintenance information for each device, they are included here for convenience.
- **Appendix D, “Measurement Conversion Tables,”** contains conversion tables from English measurements to metric and from metric measurements to English.
- **Appendix E, “Work Sheets,”** provides work sheets that may be reproduced and used for problem determination or to provide a permanent account record.

Prerequisite Publications

Before you perform link problem determination using this publication, perform the maintenance procedures contained in the following publications:

- Use *Enterprise Systems Connection Link Fault Isolation,* SY22-9533, to isolate ESCON link problems at a system level.
- Use the applicable maintenance or service information publications for all ESCON devices installed on the link to determine proper operation of those devices.

When this publication and other maintenance or service publications direct you to clean the fiber optic components, use the publication *Fiber Optic Cleaning Procedures,* SY27-2604.

Where to Find More Information

The following publications contain information related to the information in this publication:

- *Planning for Fiber Optic Channel Links,* GA23-0367, provides information that can be used when planning for ESCON links.
- *2029 Fiber Saver Planning and Maintenance*, SC28-6801
- *2029 Fiber Saver Maintenance Information*, SC28-6807
- *2029 Fiber Saver Planning and Operations Guide*, SC28-6808
- *Coupling Facility Channel I/O Interface Physical Layer,* SA23-0395.
- *Technical Service Letter No. 147 Fiber Optic Tools and Test Equipment* (Revised 2/19/96 or later), contains a complete list of fiber optic support tools and test equipment.

Coupling facility channel links are designed to be optically compatible with the F0 or physical layer industry standard *ANSI Fiber Channel Standard Physical and Signaling Interface (FC-PH)*, published by the *American National Standards Institute,* New York, NY.

The open fiber control (OFC) timing for 531 megabits per second links follows this ANSI standard. The OFC timing for 1.0625 gigabits per second links uses the same timing as specified in the ANSI standard for 266 megabits per second links, which allows longer distances for gigabit links.

How to Send Your Comments

Your feedback is important in helping to provide the most accurate and high-quality information. Send your comments by using Resource Link at *http://www.ibm.com/servers/resourcelink*. Select **Feedback** on the Navigation bar on the left. Be sure to include the name of the book, the form number of the book, the version of the book, if applicable, and the specific location of the text you are commenting on (for example, a page number or table number).

Chapter 1. Introduction to Fiber Optic Links

This chapter provides a brief introduction to fiber optic information transfer, lists the components that can be included in an IBM fiber optic channel link, and shows an example of a fiber optic channel link.

Unidirectional Fiber Optic Information Transfer

Information transfer through an optical fiber usually occurs in only one direction by using a transmitter and a receiver (Figure 1-1). The transmitter accepts encoded digital information, converts it into an optical (light) signal, and sends it through the fiber. The receiver detects the optical signal, converts it into an electrical signal, and amplifies it. The decoded digital information (output) is then the same as the encoded digital information (input).

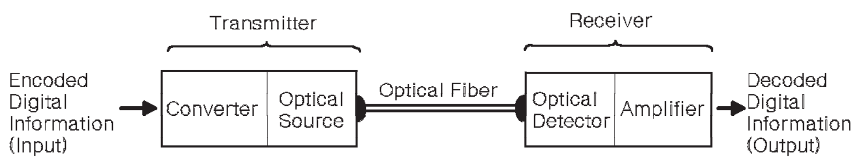


Figure 1-1. Unidirectional Fiber Optic Information Transfer

Bidirectional Fiber Optic Information Transfer

Fiber optic information transfer can also occur in two directions simultaneously (Figure 1-2). This method uses 2 optical fibers contained in 1 duplex fiber optic cable and combines the transmitter, receiver, and duplex receptacle functions into 1 transmitter-receiver subassembly (TRS) in each device.

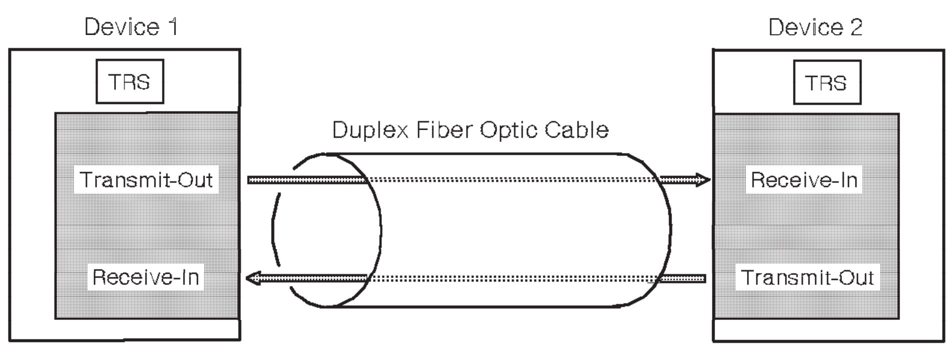


Figure 1-2. Bidirectional Fiber Optic Information Transfer

Optical Fiber Elements and Optical Cable

Note that the term *Fibre* is used in the ANSI Fibre Channel Standard documents to denote both copper and optical fiber media.

The fiber element within an optical cable usually consists of a core and a cladding (Figure 1-3). The core provides the light path, the cladding surrounds the core, and the optical properties of the core and cladding junction cause the light to remain within the core.

Although the core and the cladding diameters, expressed in micrometers (µm), are often used to describe an optical cable, they actually indicate the physical size of the fiber element. For example, a fiber element having a core diameter of 62.5 µm and a cladding diameter of 125 µm is called 62.5/125 µm fiber.

In an optical cable, the core and cladding are typically surrounded by other layers (such as a primary and secondary buffer), a strength member, and an outer jacket (Figure 1-3) that provide strength and environmental protection.

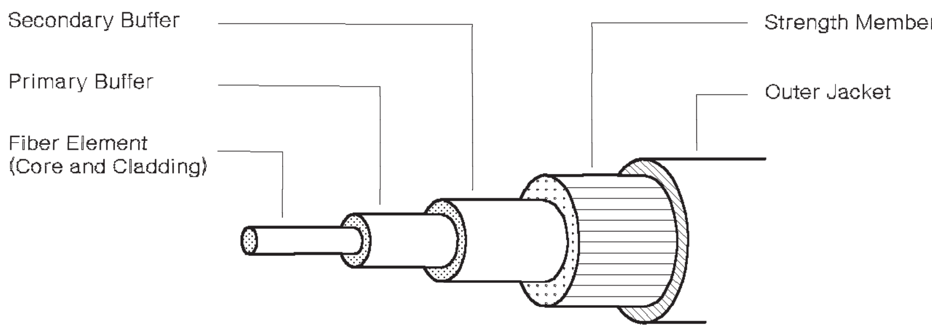


Figure 1-3. Typical Optical Cable Elements

Because information transfer usually occurs in only one direction through an optical fiber, various fiber types have been developed for different applications. The properties and specifications of an optical fiber determine many characteristics. For example, **single-mode** fiber (nominally about 9.0 µm) provides a single high-bandwidth information “path”. Single-mode fiber is normally used to transfer information over greater distances compared to **multimode** fiber (62.5 µm, for example), which provides multiple paths and has a lower bandwidth. The terms single-mode and multimode are often used interchangeably to describe both the optical fiber and the cable types.

Generally, laser diodes use single-mode fiber to transmit information while light-emitting diodes (LEDs) use multimode fiber. An exception is the multimode coupling facility channel, which uses a laser source and 50 micron multimode fiber. In a data processing environment using optical fiber, product, distance, and right-of-way considerations usually determine if single-mode or multimode fiber is used.

Optical Cable Connectors

Optical cable connectors allow manual coupling and uncoupling of the fibers but contribute to link attenuation (loss). Although several connector types have been developed to minimize this loss, all connectors can be classified as either physical-contact or nonphysical-contact connectors.

Physical-Contact Connectors

Physical-contact connectors, sometimes referred to as butt-coupled connectors, have a polished end-face surface with a slight outward (convex) curvature. When inserted into the receptacle, the fibers are precisely aligned and touch each other, thereby allowing maximum light transfer and minimum return loss. The IBM duplex connector (Figure 1-4 on page 1-4), the ST connector (Figure 1-6 on page 1-4), the Fiber Channel Connection (FICON) SC-duplex connector (Figure 1-7 on page 1-4), the FC connector (Figure 1-8 on page 1-5), the IBM FDDI connector, also known as a Media Interface Connector (MIC) (Figure 1-11 on page 1-5), the MT–RJ connector (Figure 1-12 on page 1-5) and the LC connector (Figure 1-13 on page 1-6) are types of physical-contact connectors.

IBM duplex connectors, which combine the transmit and receive signals in one housing, provide high reliability and have low loss characteristics. They are keyed to provide correct orientation and use release tabs to prevent accidental removal.

Some IBM duplex connectors and receptacles used for single-mode fiber have additional keying. This prevents the plugging of multimode IBM duplex connectors into IBM products having single-mode receptacles.

The Fiber Channel Connection (FICON) SC-duplex connector is another type of connector which may be keyed to prevent accidental plugging of a multimode fiber into a single-mode receptacle, and to provide correct orientation to the TRS. The FDDI MIC connector uses special keys to provide correct orientation (Figure 1-11 on page 1-5).

The MT–RJ connector has distinct male ends (with metal guide pins) and female ends (with guide holes). Only male to female connections will transmit optical signals. Since all MT–RJ transceivers have a male interface, only female jumper cables are required for most installations.

For single-mode ESCON links, the SC-duplex connector may be used on both the transceiver receptacle and the fiber optic cable as an alternative to the single-mode ESCON connector and receptacle. The SC-duplex connector and receptacle are defined as part of the ANSI Fiber Channel Standard Physical and Signaling Interface (FC-PH) ref. X3T9.3/755D. The connector is shown in Figure 1-7 on page 1-4; it is the same connector which has been adopted for other industry standard data links including FICON, ATM, and low cost (LC) FDDI. For single-mode ESCON links, the transceiver receptacle and connector is gray and the optical fiber cable is yellow, conforming to the established color coding for single-mode ESCON channels. The SC-duplex receptacle and connector are keyed to prevent accidental plugging of a multimode fiber into a single-mode receptacle. All of the physical layer characteristics for the single-mode ESCON interface must still be maintained by transceivers and cables using this alternative interface.

Nonphysical-Contact Connectors

Nonphysical-contact connectors do not allow the fiber end-faces to touch. Because an air gap exists, these connectors typically have a higher interface loss compared to physical-contact connectors. The biconic connector used by IBM (Figure 1-9 on page 1-5), which is equivalent to AT&T part number 1006A, is an example of a nonphysical-contact connector.

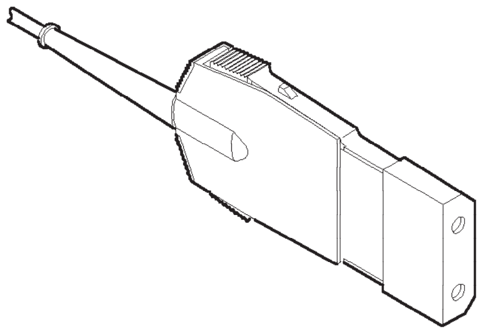


Figure 1-4. IBM Duplex Multimode Connector

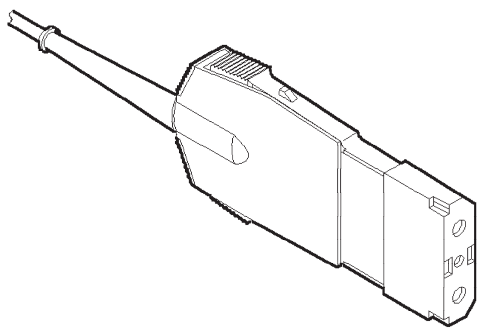


Figure 1-5. IBM Duplex Single-Mode Connector

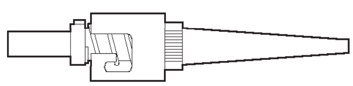


Figure 1-6. ST Physical-Contact Connector

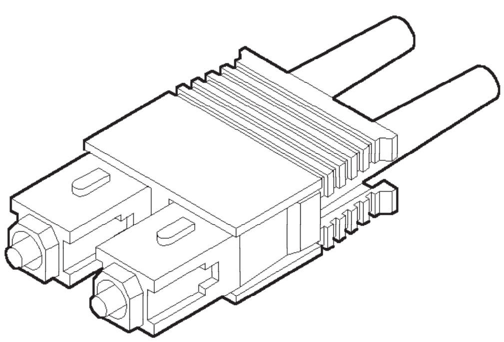


Figure 1-7. FICON SC-Duplex Connector

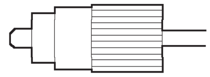


Figure 1-8. FC Physical-Contact Connector

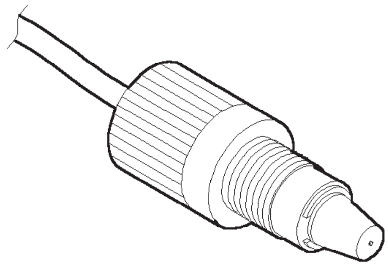


Figure 1-9. Biconic Nonphysical-Contact Connector

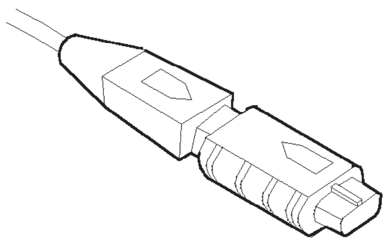


Figure 1-10. Multifiber Terminated Push-on Connector (MTP). Twelve fiber connector available on IBM Global Services trunk cables and harnesses.

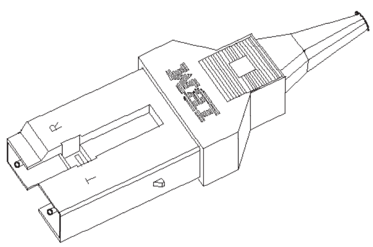


Figure 1-11. MIC (FDDI) Connector

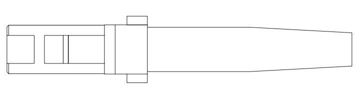


Figure 1-12. MT–RJ Connector

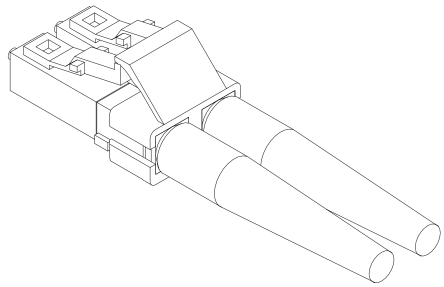


Figure 1-13. LC Duplex Connector

Connector Color Coding

IBM simplex connectors use color-coding to show the direction that light travels through a link (see "Determining the Direction of Light Propagation" on page 2-7). These connectors are black (or use a black marking) and white (or use a white marking).

IBM duplex cable connectors use color-coding to differentiate between multimode and single-mode. Multimode cables have black connectors and single-mode cables have gray connectors. They do not require color coding to determine the direction that light travels, or propagates, through the cable because the connectors are physically keyed. This provides proper orientation and allows the fibers to be labeled "A" and "B", which is shown on the connector. See"Determining the Direction of Light Propagation" on page 2-7.

The FICON SC-duplex connector is an industry standard optical connector (as defined in *ANSI Fiber Channel Standard Physical and Signaling Interface (FC-PH)*, published by the *American National Standards Institute.* Since it may be purchased from a variety of vendors, there is no consistent scheme of color coding or labeling the ends of a simplex cable with FICON SC connectors. These connectors can be identified by their shape (see Figure 1-7 on page 1-4) and the direction of light propagation must be verified from the vendor specifications. For IBM supplied cables, the single-mode FICON jumper has a yellow connector with grey clip and a yellow cable jacket, while the multimode has a blue connector with black clip and an orange jacket. This is the same color scheme used for ESCON connectors and cables.

IBM Jumper Cables

IBM provides both single-mode (yellow) and multimode (orange) jumper cables, which attach either between two devices or between a device and a distribution panel.

Note: A fiber optic channel link (device-to-device connection) must consist entirely of either single-mode or multimode cables.

The elements in an IBM duplex jumper cable (Figure 1-14) consist of 2 tight-buffered optical fibers (core and cladding) surrounded by a strength member, all of which are encased in a common flexible jacket. Duplex cables for coupling facility channels (or ESCON XDF™) (Figure 1-15) are similar, except that they are not encased in a single jacket. Both single-mode and multimode jumper cables have a cladding diameter of 125 µm. Single-mode cable has a mode field diameter (MFD) of about 9 µm; multimode cable has a core diameter of either 62.5 µm or 50.0 µm.

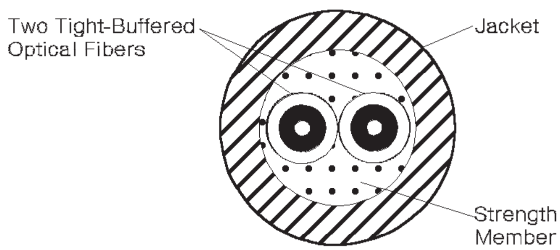


Figure 1-14. IBM Duplex Jumper Cable Elements

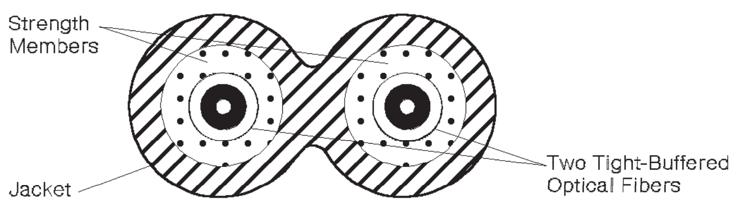


Figure 1-15. Coupling Facility or ESCON XDF Jumper Cable Elements. (Jumper cables which use FICON SC duplex connectors.)

All IBM jumper cables have a duplex connector on one end, which attaches to a fiber optic channel link device. Attaching a jumper cable to a distribution panel, however, could require jumper cables with other connector types (see "Optical Cable Connectors" on page 1-3). IBM offers these jumper cables:

- **Single-mode and multimode applications:**
  - Duplex-to-duplex jumper cables have an IBM duplex connector on both ends.
  - Duplex-to-duplex jumper cables have an FICON SC duplex connector on both ends.
  - Duplex-to-duplex jumper cables have an LC duplex connector on both ends.
  - Duplex-to-duplex jumper cable conversion kits:
    - IBM duplex receptacle on one end and an FICON SC duplex connector on the other end.
    - An LC connector on one end and a duplex receptacle on the other end.
- **Multimode applications only:**

– Duplex-to-biconic jumper cables have a pair of color-coded biconic connectors on one end and are available to support the 3044 Models C02 and D02.
– Duplex-to-ST jumper cables have a pair of color-coded, physical-contact ST connectors on one end.
– Duplex-to-FC jumper cables have a pair of color-coded, physical-contact FC connectors on one end.
– Duplex-to-unterminated jumper cables have an unterminated end (no connector) that allows the attachment of any connector type.
– Duplex-to-duplex jumper cables with female MT–RJ on both ends.
– Duplex-to-duplex jumper cables with male MT–RJ on both ends.
– Adapter kits:
  - ESCON receptacle to female MT–RJ connector
  - ESCON connector to female MT–RJ connector

Note: If a single-mode ESCON XDF link using the SC-duplex connector interface must be connected to a single-mode ESCON XDF connector interface, use the ESCON XDF Adapter Kit (46H9223). The kit consists of a 2-meter single-mode jumper cable with SC-duplex-to-ST connectors (46H9222) assembled to the single-mode ESCON-to-ST adapter. Instructions are provided with each kit.

Trunk Cable

Fiber optic trunk cable is generally used for longer links, such as between floors or buildings. It should also be used in single-floor fiber optic channel link environments when many jumper cables and connections are required. If trunk cable is used, distribution panels must provide the hardware used to attach the IBM jumper cables.

A trunk cable typically contains from 12 to 144 fibers and has a strength member and an outer jacket. Each fiber optic channel link requires trunk fibers. The physical trunk cable configuration varies and depends on user requirements, environmental conditions, and the type of installation required (for example, above ground or underground).

Splices

Fiber optic trunk cables can be joined by two splicing methods. Either method, when performed by a trained technician using high-quality materials, can produce a splice having a very low optical power loss.
- Fusion splices are joined by an electric arc.
- Mechanical splices are joined within a holder and sometimes use epoxy to bond the fibers.

Distribution Panels

Many types of distribution panels exist. They are available in various sizes and styles and are called different names, depending primarily on their application or use. For example, they can be called central distribution panels, main distribution panels, zone panels, patch panels, building interface panels, enclosures, or cabinets. In a fiber optic channel link, they provide the hardware attachment capability between trunk cables and IBM jumper cables. They can also be used for

floor-to-floor cable connections within a building or for connections between buildings. For more information about distribution panel requirements, contact your IBM marketing representative.

Couplers and Adapters

Distribution panels must provide couplers or adapters to allow attachment of IBM jumper cables. Couplers join **the same** connector types, while adapters join **different** connector types. The following couplers and adapters, available from IBM, are shown in Figures Figure 1-16 through Figure 1-23. Other types of adapters for patch panels may be available as RPQs, including the FICON SC-duplex-to-ST adapter. A conversion kit is available to adapt an FICON duplex interface to an ESCON duplex interface.

- IBM duplex coupler
- ST coupler
- FC/PC coupler
- MT–RJ duplex coupler (joins male to female MT–RJ)
- LC duplex coupler
- IBM duplex-to-ST adapter
- IBM duplex-to-FC/PC adapter
- FICON SC-duplex-to-ST adapter
- FICON SC-duplex-to-FC adapter
- FICON SC-duplex-to-duplex coupler
- MTP-to-MTP coupler
- MIC coupler
- MIC-to-ST adapter
- MIC-to-FC adapter

Note: IBM recommends using IBM duplex-to-duplex jumper cables between ESCON-capable devices and distribution panels, FICON SC-duplex-to-duplex jumper cables between coupling facility channeldevices and distribution panels, and IBM duplex-to-ST or IBM duplex-to-FC/PC adapters in distribution panels.

Other adapters for patch panels may be available as RPQs.

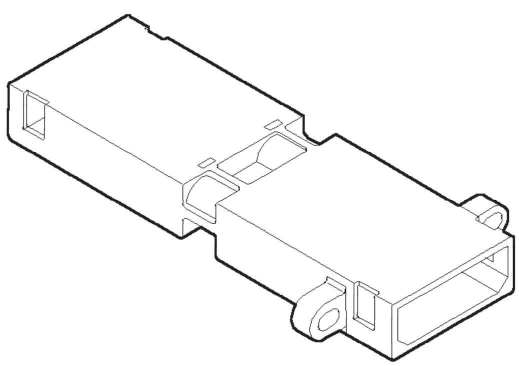


Figure 1-16. IBM Duplex Coupler

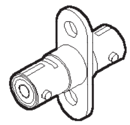


Figure 1-17. ST Coupler

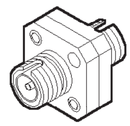


Figure 1-18. FC/PC Coupler

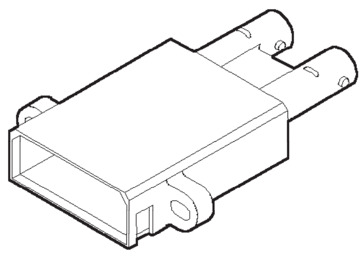


Figure 1-19. IBM Duplex-to-ST Adapter

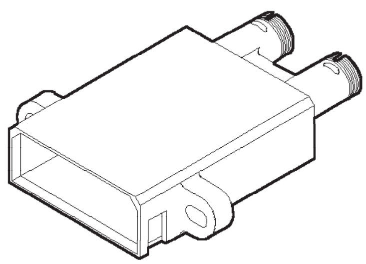


Figure 1-20. IBM Duplex-to-FC/PC Adapter

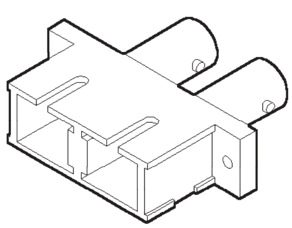


Figure 1-21. FICON SC-Duplex-to-ST Adapter

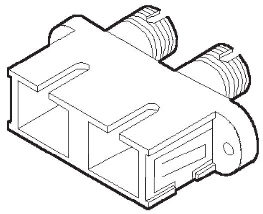


Figure 1-22. FICON SC-Duplex-to-FC Adapter

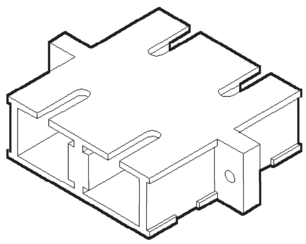


Figure 1-23. FICON SC-Duplex-to-Duplex Coupler

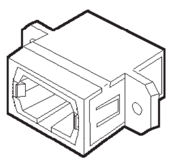


Figure 1-24. MTP-to-MTP Coupler

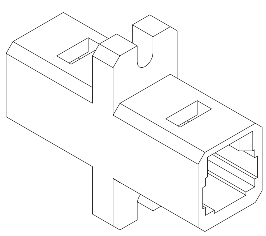


Figure 1-25. MT-RJ Coupler

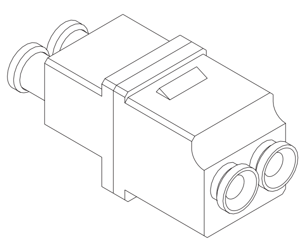


Figure 1-26. LC Coupler

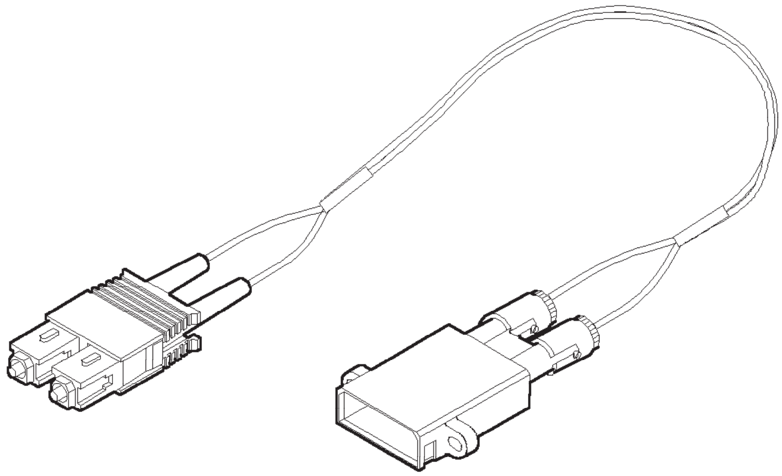


Figure 1-27. FICON-ESCON Kit

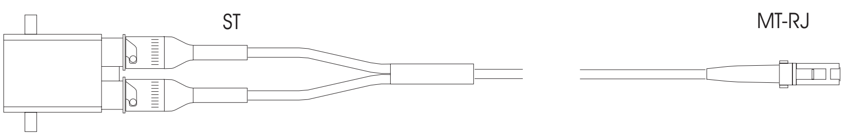


Figure 1-28. MT-RJ-to-ESCON Kit

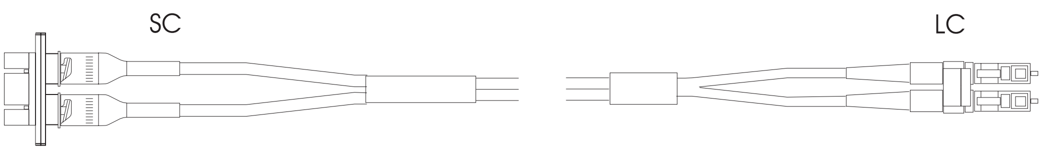


Figure 1-29. LC-to-FICON Kit

Optical Mode Conditioners

In some fiber optic applications, it is possible to use a long wavelength (1300 nm) singlemode laser adapter with multimode fiber by placing a special device known as an optical mode conditioner at both ends of the link. The optical mode conditioner resembles a standard 2 meter jumper cable, and is sometimes known as a mode conditioning patch cable (MCP). As shown in Figure 1-30 on page 1-14, the MCP is unique in that it contains both singlemode (yellow) and multimode (orange) fibers in a single jumper cable assembly. Without the MCP, it is not possible to use a singlemode laser transmitter over multimode fiber because the laser source does not launch an equal amount of optical power into all modes of the fiber; this leads to excessive dispersion of the data pulses, and the link will not function. The MCP is designed to “condition” the laser launch so that the optical power fills all modes of the fiber equally.

Because of the bandwidth limitations of multimode fiber, future multi-gigabit fiber optic interconnects will likely be based on singlemode fiber cables. However, many current applications use multimode fiber extensively. There is a need to re-use the large installed base of multimode fiber as long as possible; the ability to continue using installed fiber with new adapter cards also facilitates migration to higher data rate links. The need to migrate from multimode to singlemode fiber affects all of the major datacom applications:

- Using MCPs, it is possible to run singlemode (LX) FICON channels over multimode fiber at reduced distances [550 meters (.31 miles)]. I/O applications currently using multimode fiber for ESCON will need to migrate the cable plant to singlemode fiber in order to take full advantage of the extended distance FICON links. For shorter distances [<550 meters (.31 miles)], short wavelength FICON SX links may be used over multimode fiber. Future FICON enhancements which extend this protocol to multi-gigabit data rates will also require singlemode fiber.
- Networking applications such as ATM have traditionally used different adapter cards to support multimode and singlemode fiber. The Gigabit Ethernet standard (IEEE 802.3z) allows the use of both fiber types with the same adapter card, and support the use of MCPs.
- Coupling links for Parallel Sysplex® were originally offered as either 50 Mbyte/s data rates over 50 micron multimode fiber (using short wavelength 850 nm lasers) or 100 Mbyte/s data rates over singlemode fiber (using long wavelength 1300 nm lasers). In May 1998 support for multimode fiber was withdrawn. There is a need to support 100 MByte/s adapter cards over the installed 50 micron multimode fiber to facilitate migration from the 50 Mbyte/s links. This support will continue on coupling links using the LC interface; on MCP which adapts singlemode LC to multimode SC duplex is available.

The MCP is installed on both ends of a link, and occupies the same space as a standard 2 meter jumper cable. Adapter kits containing the MCPs are available with either SC duplex connectors (to support coupling links) or ESCON connectors (to support ESCON-to-FICON migration). Different MCP adapter kits are required for 50 or 62.5 micron fiber. Using the MCPs reduces the maximum link distance to 550 meters for gigabit links (see Appendix A, “Specifications,” on page A-1).

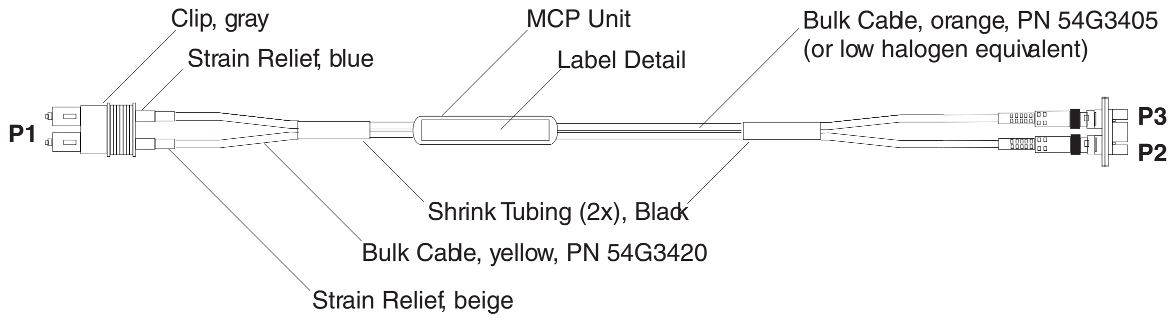


Figure 1-30. Mode Conditioner Patch Cable (MPC). Connections P2 and P3 may be terminated with either an SC duplex or an ESCON duplex coupler. Connector P1 is available in either an SC duplex or LC duplex connector.

Splitter Tool

An optical splitter is used to measure optical power levels in a coupling facility. The optical splitter tool is shown in Figure 1-31 for multimode links and Figure 1-32 for single-mode links.

Refer to “Isolating Link Segments Using the Splitter Tool” on page C-20 for more information.

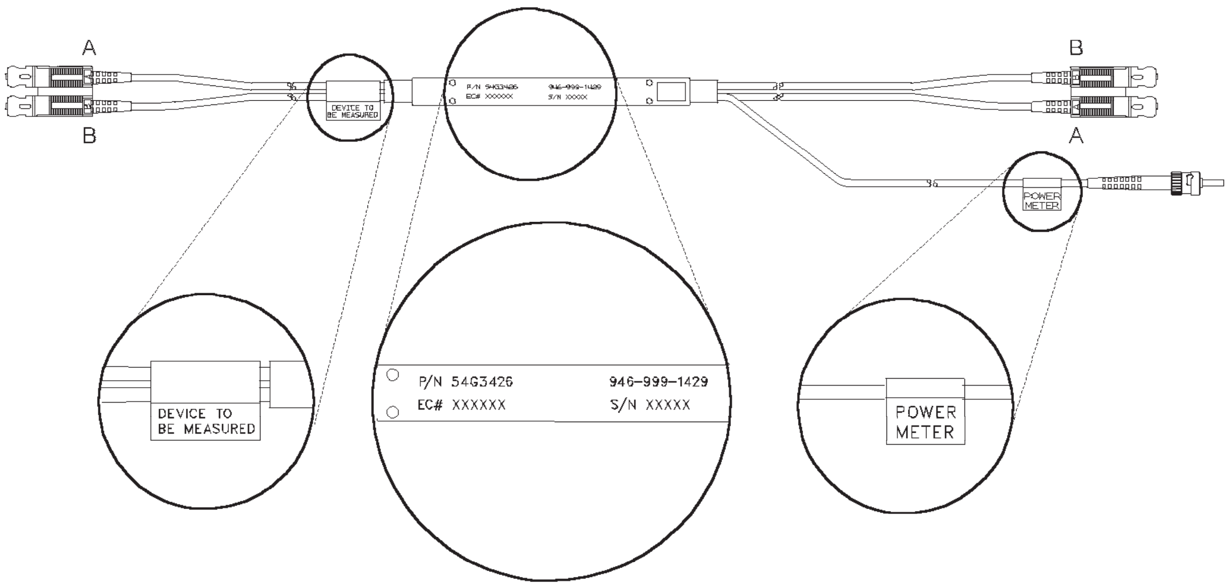


Figure 1-31. Optical Splitter Tool for Multimode Links

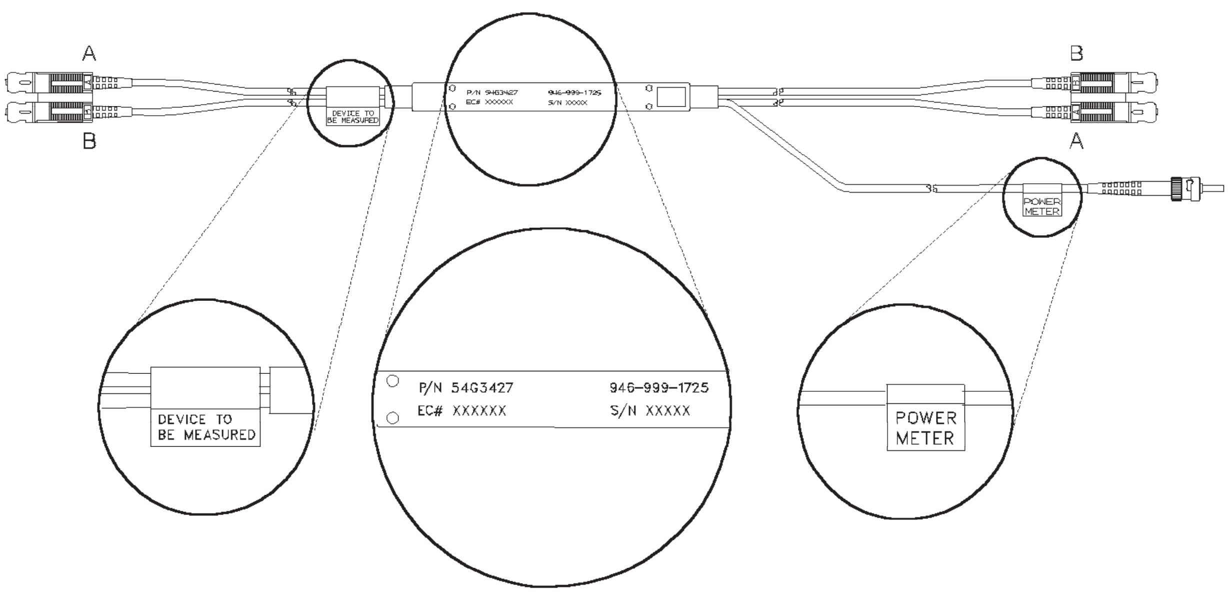


Figure 1-32. Optical Splitter Tool for Single-Mode Links

Fiber Optic Channel Link Configuration

Note: IBM offers help in the planning, design, and installation of fiber optic channel links through its Connectivity Services offering (Fiber Transport System) of IBM Global Services. For more details, contact your IBM marketing representative. Also, the IBM Fiber Transport Services (FTS) offering provides planning assistance, commodities, and installation for multimode and single-mode fiber trunk systems.

Fiber optic channel links, which require separate optical fibers for sending and receiving information, use IBM duplex or FICON duplex connectors, duplex jumper cables, and 2 trunk fibers. A fiber optic channel linkcould consist of only 1 jumper cable that connects devices, or it could have many cables, distribution panels, adapters, couplers, and connectors.

Regardless of the number of cables and components, a fiber optic channel link attaches 2 devices and **must consist entirely of either single-mode or multimode cables**.

Figure 1-33 shows an example of a fiber optic channel link having:
- Two IBM duplex-to-duplex jumper cables
- Two distribution panels, each containing an IBM duplex-to-ST adapter
- Four ST connectors
- Two trunk cable fibers
- Four trunk cable splices

Important

IBM duplex-to-duplex jumper cables should be used between ESCON devices and distribution panels, FICON SC duplex-to-duplex jumper cables should be used between coupling facility channel devices and distribution panels, and IBM duplex-to-ST, or IBM duplex-to-FC adapters should be used in distribution panels.

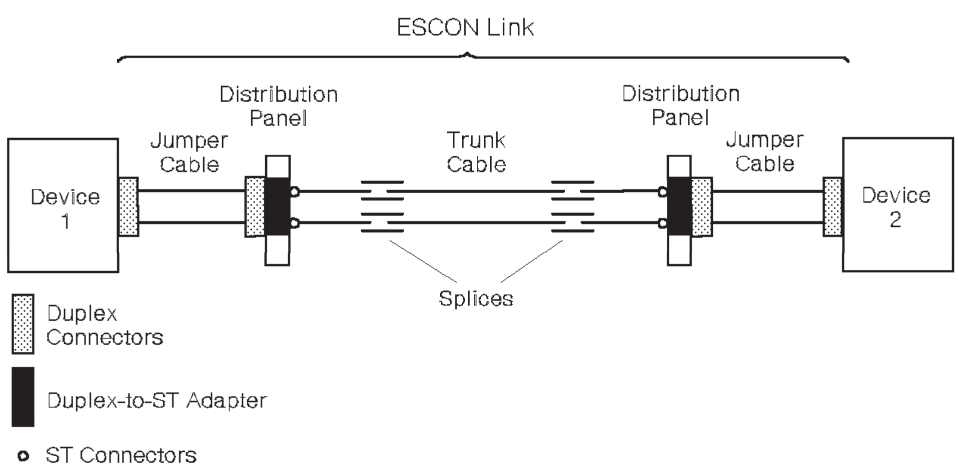


Figure 1-33. Example of Components in a Fiber Optic Channel Link.

In an OSA link (FDDI, ATM, or GbE) environment, a link consists of the physical connection between the TRS of one device and the TRS of another device.

An FDDI link can consist of one access station connected to a concentrator, or a concentrator connected to a concentrator on a dual access counter-rotating ring (other point-to-point configurations are also possible). Individual FDDI access stations are electronically made into logical rings at the concentrator. Concentrators with counter-rotating rings also have the connections managed electronically. The physical FDDI connection, however, is handled by placing *primary out* and *secondary in* into one MIC housing and *primary in* and *secondary out* in the other MIC housing. Figure 1-34 shows a possible FDDI link employing a device-to-concentrator connection.

Links other than FDDI may not use concentrators or hubs, but will usually run to switches or distribution panels.

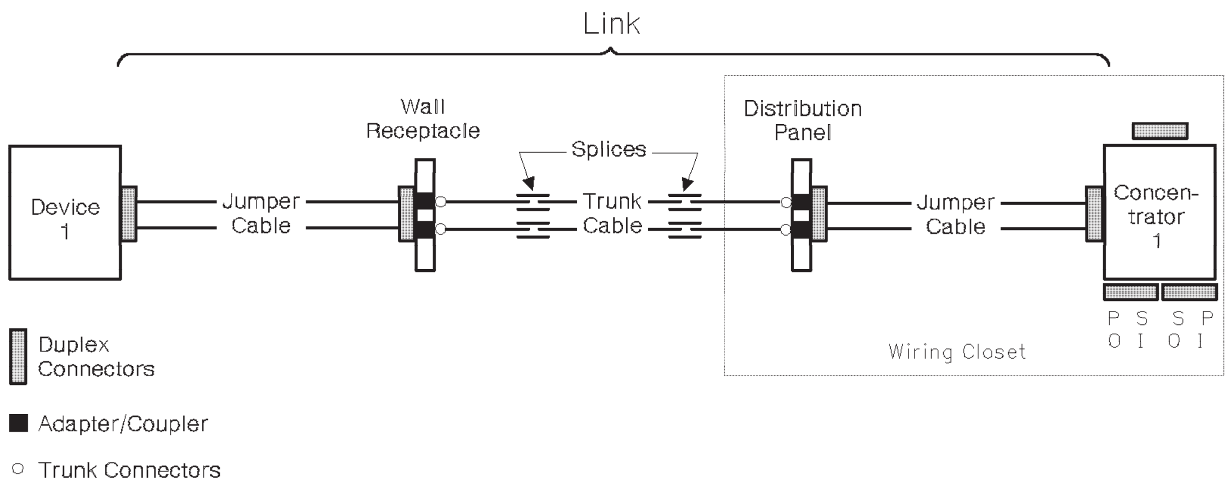


Figure 1-34. Components in a Typical Link

FDDI Service Limitations

The following paragraphs describe limitations that could exist while servicing FDDI links; they do not apply to other types of fiber optic links.

Jumper Cable

The FDDI specifications for connector design are not specific enough to guarantee that every FDDI connector will work with every product under all conditions. IBM recommends the use of IBM jumper cables with IBM products to meet FDDI specifications and to ensure performance expectations. Some jumper cables used with IBM products might not yield the correct amount of launched power. An Original Equipment Manufacturer (OEM) product might use a jumper cable other than IBM's for the same reason.

Note: The amount of power launched from the device into the fiber is affected by the connector-to-device interface and the fiber size. IBM jumper cables can be directly connected to an OEM device and measurements will be accurate if the device manufacturer has specified IBM jumper cables as acceptable. Other measurements at any connection in the link or the end-to-end link loss measurement are *not* subject to this condition.

Link Bandwidth

An FDDI multimode link can be limited by dispersion instead of attenuation. Link length, fiber type, fiber specifications, transmitter spectral width, and transmitter center wavelength are factors that have the potential to produce FDDI link errors. This potential can exist even if all factors are within the FDDI specifications. However, if the link is 2 km or less and consists of optical fiber that is 500 MHz•km at 1300 nm or better, excessive attenuation, not dispersion, is the most probable cause of the problem.

Note: Optical bypass switches, although permitted in the FDDI standard, make the link longer. This can cause a link to become inoperative due to dispersion, even if attenuation is within specification.

Link Error Conditions

There are 2 basic types of link error conditions:

- A link failure occurs when the receiver does not detect a signal, which is usually caused by a:
  - Weak or defective transmitter or receiver
  - Defective jumper cable
  - Dirty or misplugged connector
  - Defective or misplugged segment of the optical fiber cabling.
- A link error occurs when the status of one or more bits has changed, which is usually caused by:
  - A weak transmitter or receiver
  - A dirty or misplugged connector
  - A dirty transmitter-receiver subassembly
  - An incorrect transmitter-to-receiver relationship
  - Excessive link attenuation
  - Dispersion of the link signal.

Link Error Analysis

Because dispersion is not usually measured in the field, it is important to determine if attenuation is the most likely cause of a link failure. Therefore, analyze the failing link environment before proceeding with fault isolation.

The following questions can help isolate the error when performing link failure analysis.

- What is the status of similar links and devices?
- Are there any substitute devices?
- Are there any spare optical fiber pairs?
- Is this the first time that the failing link or links have been used?
- Has this cabling combination been used before?
- If it is an FDDI link, has an optical bypass switch been installed in the link?
- Has this cabling combination been used for another application that had a different wavelength?
- Is the cabling plant a new installation?
- Was the cabling plant installed to support an ESCON, ATM, FICON, or FDDI environment?
- Was the cabling plant installed over a period of time?
- Was the cabling plant previously used to support other applications?
- Is there a mixture of fiber types within the cabling plant?
- Is there a mixture of fiber types within the same distribution panel?
- Is there a mixture of applications using the same distribution panel?
- Is this the first time that part of the cabling plant was configured in the link?
- Are the cabling plant lengths and specifications available?

Examples of Link Error Analysis

The following examples show how experience and good diagnostic judgment can aid in error analysis for a link environment.

- The failing link uses the same cabling components, has approximately the same length, and attaches the same device types as another link that is currently operational. It is most likely that attenuation, not dispersion, caused the link error.
- The failing link operates correctly when a substitute device is attached. Again, attenuation is probably the cause of the error.
- The failing link operates correctly when substitute link components (spare or backup cables) are used. Attenuation is usually the cause of the error.
- All links with this configuration are failing. If attenuation measurements are within specifications, the length of the link and optical fiber specifications should be checked.
- The failing link has never been used before. The length of the link and optical fiber specifications should be checked if attenuation measurements are within specifications.
- The failing link is the only link in this location. If attenuation measurements are within specifications, the length of link and fiber plant specifications should be checked.
- The failing link was previously used for an entirely different type of system. If a customer determines that the link was optimized for an application employing a wavelength other than 1300 nm, then excessive dispersion could be the cause of the error.

Dispersion

Under some conditions (in an FDDI link only), it is difficult to determine if the most probable cause of an error is attenuation or dispersion (for example, a link of 2.1 km with an attenuation of 11.3 dB). Because dispersion testing is an expensive procedure, it might be more cost-effective for the customer to reconfigure the link or replace the fiber rather than determine the exact cause of the failure. The following items can aid in this analysis:

- Customer records of the measurements done by cabling installation personnel can be checked. These records often include attenuation measurements from a power meter, as well as a copy of Optical Time Domain Reflectometer (OTDR) data.
- It is possible that a given pair of attached devices meets FDDI specifications because of a “hot” transmitter and a sensitive receiver. This combination could allow satisfactory operation for a specific link, but the individual link components are still not within specifications. This combination is not possible under the ATM or FICON specification.
- Similarly, a weak transmitter and receiver pair could meet FDDI specifications but still not operate correctly on the link.

Chapter 2. Service Strategy and Maintenance Activities

This chapter summarizes the service strategy and activities associated with Fiber Optic Channel link installation, maintenance, problem determination, verification, repair, and testing. See Chapter 3 for specific maintenance procedures.

Additional services, including design, installation connectivity, and link restoration are available through the IBM Global Services offering.

Link Problem Determination Summary

Service representatives can use either the maintenance analysis procedures (MAPs) or a “fast-path” method to perform problem determination, and return a link to operational status for ESCON links. For coupling facility channel links, only the Fast-Path method may be used because these links use a different type of laser safety control that does not permit use of the MAPs. This problem determination also includes IBM jumper cables.

Both procedures consist of measuring the end-to-end link loss (attenuation) using an optical source and a power meter. Since the safety controls for the coupling facility channel do not permit the laser to remain operational when the link is open, the device transmitter must be used along with an optical splitter to measure the end-to-end link loss. See Appendix B, “Tools, Test Equipment, and Parts,” on page B-1 for the part numbers of all service tools, materials, and test equipment.

Link Service Activities

The following paragraphs summarize the link activities performed by service representatives.

Installation Activities

Service representatives install and connect IBM jumper cables to devices and distribution panels. For installations that use connectors or cables other than those supported by IBM, IBM Marketing and Services must provide recommendations to the customer and to IBM planning and service personnel.

Repair Activities

Service representatives perform either major or minor repair actions:

- A major repair action consists of replacing an IBM jumper cable.
- A minor repair action consists of replacing the spring and connector shroud on the IBM duplex connector.

Test Activities

Service representatives also perform test activities on IBM fiber optic cables and components.

For non-IBM components, the customer must provide test cables and adapters. IBM will perform activities relating to these components, but this service could be billable.

Link Training Topics

The base level of link training for IBM CEs includes:
- Basic fiber optic theory
- Light budget concepts
- General link commodities information
- Link loss calculations
- Link operational characteristics
- Fiber optic cable handling and cleaning procedures
- Power meter and light source usage procedures
- Basic fiber optic test procedures
- Problem determination for a major link component
- Minor repair of the IBM duplex connector.

Keying and Installing an IBM FDDI Connector

This section describes how to install FDDI keys and labels. It also lists some potentially serious cabling errors and explains the keying techniques that could prevent these errors. (LC FDDI, FICON and ATM do not use these keying methods.)

Note: Retain all protective covers and unused keys. When connectors and receptacles are not being used, all protective covers should be installed because dirt can cause excessive loss and prevent correct operation of the link.

Using FDDI cable keying can also prevent system cabling defects that are difficult to detect and diagnose. Three serious defects are:
- The reversal of a dual-attachment station within the ring trunk such that what was intended to be the A connection is the B, and what was intended to be the B connection is the A. This causes the station media access controls (MACs) to be inserted in the opposite position of the intended trunk ring.
- The connection of a single attachment station directly to the trunk ring by connecting it to either an A or B receptacle. This results in a break in the trunk ring.
- The connection of the M receptacle of a concentrator directly into the trunk ring by connecting it to either an A or B receptacle. This also results in a break in the trunk ring.

IBM FDDI Connector Keys

The FDDI standard specifies four types of keyed connectors and receptacles: A, B, M, and S. Three field-installable key inserts and four color-coded labels are provided with each connector:
- Port A — Red key and red label
- Port B — Blue key and blue label
- Master — Green key and green label
- Slave — No key and white label.

Each connector assembly comes with a set of color-coded labels to identify a keyed connector after it has been inserted in a receptacle. To position the label on the connector, select the label that matches the key type being used. White labels identify the Slave (S) connector, which does not have a separate key. Position the label on the back of the connector. See Table 2-1 on page 2-3.

Note: Without a key installed, the connector can be inserted in any type of FDDI receptacle. Correct keying is recommended to avoid installation errors and to provide efficient cable management.

Table 2-1. IBM Recommendations for Keying FDDI Networks

Connection	Key Type
Workstation to wall	S / S
Distribution panel to Concentrator M port	M / M
Distribution panel to Concentrator A port	A / A
Distribution panel to Concentrator B port	B / B
Concentrator A to Concentrator M port	A / M
Concentrator B to Concentrator M port	B / M
Concentrator 1A to Concentrator 2B port	A / B
Concentrator 1B to Concentrator 2A port	B / A
Workstation to Concentrator M port	S / M

Installing the Key

To install a key:

1. Remove the selected color-coded key from the protective cover of the connector.
2. Insert the tab on the key in the slot on the top of the connector.
3. Push firmly on the key until it snaps into place.

Removing the Key

To remove a key:

1. Insert the tip of a paper clip or narrow mechanical pen into the small hole in the bottom of the connector.
2. Push firmly until the key pops out of its locked position.
3. Put the key in the protective cover attached to the connector.

Cleaning the Connector

The connector should be cleaned before inserting it in the receptacle to avoid possible contamination from dirt and dust particles. Refer to *Fiber Optic Cleaning Procedures*, SY27-2601.

Installing and Removing the Connector

Insert the connector by pushing it into the receptacle until it clicks into place. Do not force the connector. If it binds, make sure that the receptacle and connector keys are aligned and that they are of the same type.

To remove the connector from the receptacle, simply pull back on the connector housing. Replace all protective covers on the connector and the receptacle to avoid contamination or damage.

Typical Link Configurations

To perform problem determination, a fiber optic channel link should be considered as one of the following configurations:

- One jumper cable between 2 devices (Figure 2-1)
- Two jumper cables connected through 1 distribution panel (Figure 2-2)
- Two jumper cables, each connected to a distribution panel, and a trunk cable (Figure 2-3).

  Note: The trunk cable in this configuration could be a short length of fiber optic cable (within a single distribution panel) that joins the 2 jumper cables.

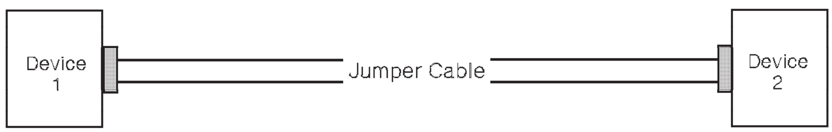


Figure 2-1. Link Configuration 1 Consisting of 1 Jumper Cable between 2 Devices

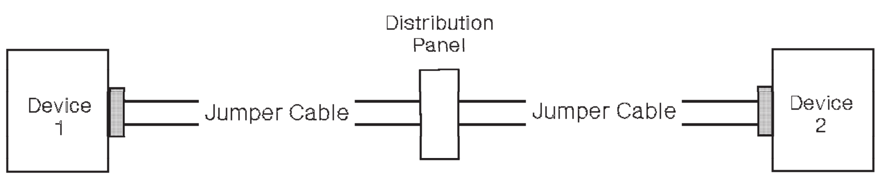


Figure 2-2. Link Configuration 2 Consisting of 2 Jumper Cables and 1 Distribution Panel

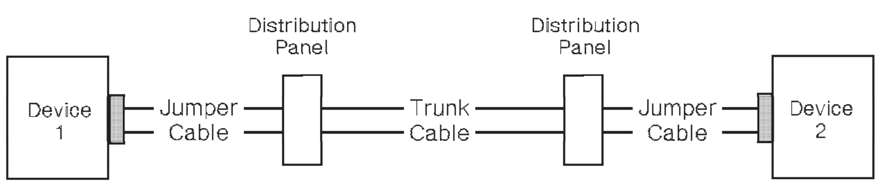


Figure 2-3. Link Configuration 3 Consisting of 2 Jumper Cables, a Trunk Cable, and 1 or 2 Distribution Panels

FDDI links connect devices in logical rings, but are physically connected in a star configuration. Devices could contain only a single pair of fibers, such as a device to a concentrator. Critical devices, such as concentrators, contain 2 pairs of fibers formed into counter-rotating rings. From this description, a concentrator would contain multiple single-station interfaces to multiple devices and a pair of interfaces to possibly another concentrator. It is likely, therefore, that several devices within a rack would be connected by jumpers only within an equipment closet, whereas 2 ports would exit the closet on counter-rotational links to other concentrators.

Other fiber optic links may be configured in a wide variety of ways, including star and ring configurations. Figure 2-4 shows a closet-connected concentrator.

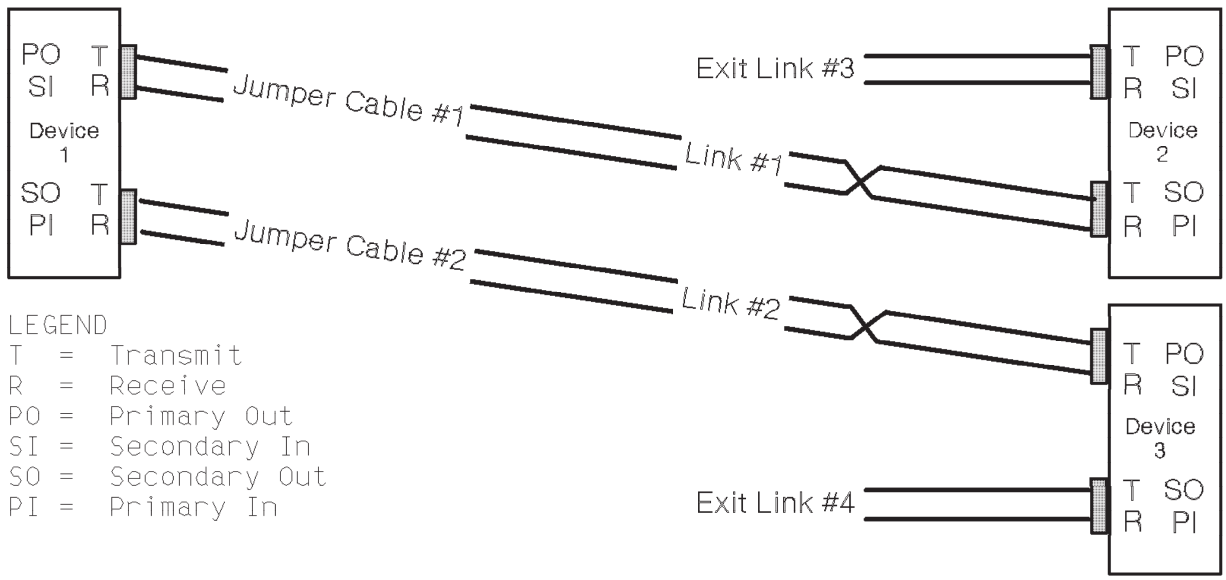


Figure 2-4. Link Configuration——Two Jumper Cables in a Counter-Rotating Ring

Common Link Failures

Before performing problem determination, you should consider the following failure possibilities, which are typical during and after installation. If the problem, symptom, or condition exists, perform the action suggested.

- For a “no-light” condition during an installation or after a reconfiguration, the link could have 2 device transmitters connected rather than having each transmitter connected to a receiver. Make sure an odd number of link crossovers exists. See “Determining the Direction of Light Propagation” on page 2-7 for more detailed information.

  If jumper cables with FICON SC-duplex connectors are provided by a vendor other than IBM, consult the vendor’s specifications to determine the correct direction of light propagation.

  After determining that a “no-light” condition exists and with the optical source and power meter attached, swap the biconic test cable connectors on the power meter. If the “no-light” condition disappears, the link is not properly connected.
- The quality and cleanliness of connections can be a large source of loss. Check for dirty or broken connectors at the devices and distribution panel(s). These problems can be found by isolating each link segment. See the publication *Fiber Optic Cleaning Procedures,* SY27-2604, and use the supplies contained in the fiber optic cleaning kit (IBM part number 5453521).
- Patch cords (used to attach 1 distribution panel position to another) can cause additional link loss in a configuration using multiple distribution panels. Isolating each link segment can determine if the IBM jumper cables are within specifications.
- Device distance limitations exist. If I/O overruns or timeouts occur, check the distance specifications of the I/O device.
- Link distance limitations also exist. See Table A-1 on page A-3 for maximum link lengths.

Determining the Direction of Light Propagation

Before performing problem determination, an understanding of light travel (propagation) is necessary to allow measurement of:

- Transmit levels
- Receive levels
- End-to-end link loss

The transmitter (output) of each Fiber Optic Channel link device propagates light to the receiver (input) of the next device. For this to occur, an odd number of physical crossovers must exist for each fiber. Figure 2-5 on page 2-8 shows the direction of light propagation through an IBM jumper cable, which is keyed to maintain this crossover requirement.

Figure 2-5 on page 2-8 also shows that an IBM duplex connector has **A** and **B** embossed on the plastic housing and that IBM's biconic, ST, and FC connectors are color-coded.

- For IBM duplex-to-duplex jumper cables, the transmit signal enters 1 connector at **B** and exits the other connector at **A**.
- For IBM duplex-to-biconic, duplex-to-ST, and duplex-to-FC jumper cables, the transmit signal enters the duplex connector at **B** and exits the other end at the **black** connector.

Figure 2-6 on page 2-8 shows three examples of physical fiber connections that satisfy the crossover requirement for device-to-device attachment.

Notes:

1. In a Fiber Optic Channel environment containing duplex-to-duplex jumper cables and a trunk cable, the trunk must incorporate a crossover.
2. Fiber Optic Cables using FICON SC-duplex connectors obtained from vendors other than IBM may not have a built-in crossover or be labeled according to the conventions above. Consult the manufacturer's specifications.
3. The coupling facility link is serviced using either the multimode splitter tool (IBM part number 54G3426) or the single-mode splitter tool (54G3427). These splitters may be inserted anywhere in an operating link without affecting link functions.
4. IBM's biconic, ST, and FC connectors are color-coded (white and black). The MIC duplex connector has the letters *R* and *T* embossed on the plastic housing.
5. Industry standard color coding for single-mode links is a yellow cable jacket with a blue duplex connector; multi-mode links use an orange cable jacket with a beige duplex connector. Not all connectors will conform to these color coding standards.

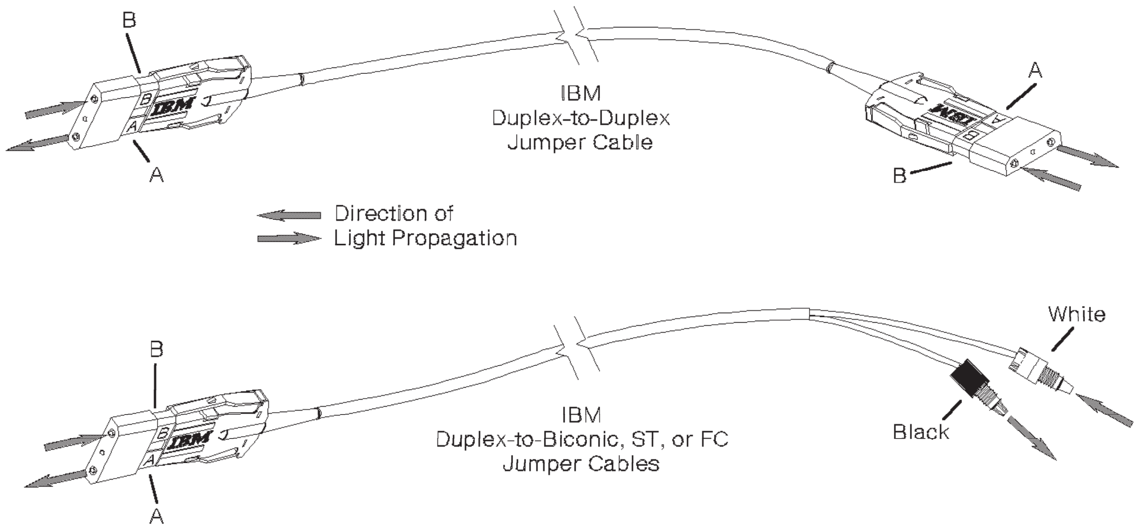


Figure 2-5. Determining the Direction of Light Propagation in IBM Jumper Cables

(ESCON connectors are shown in this figure).

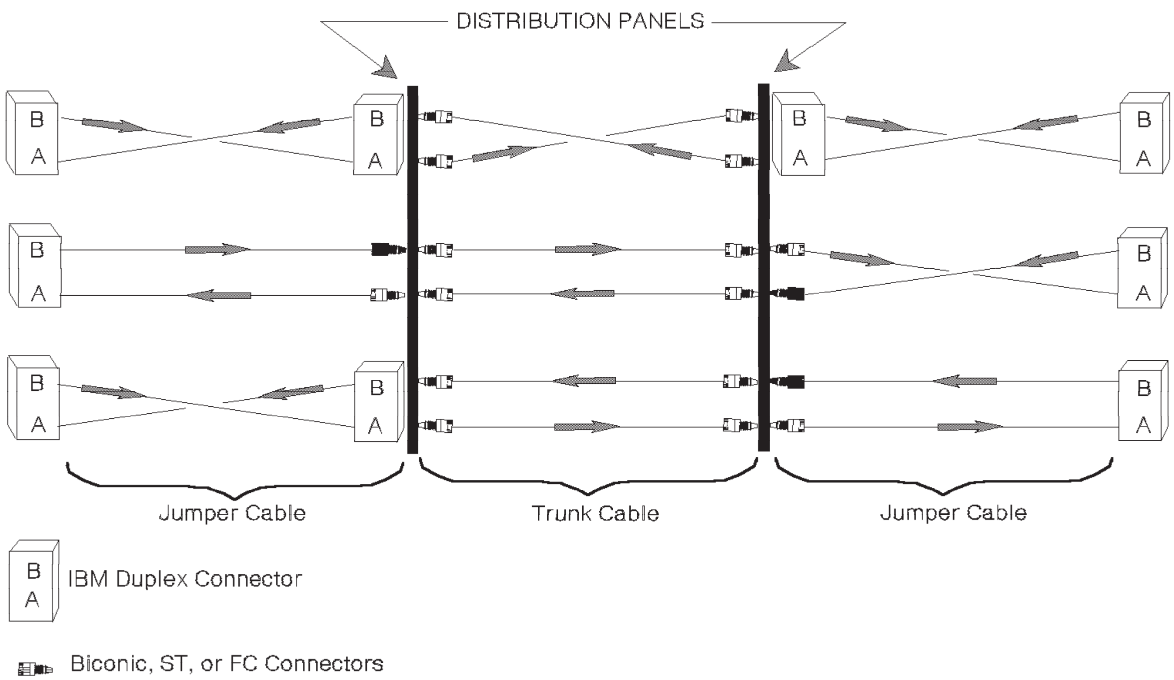


Figure 2-6. Determining the Direction of Light Propagation in Fiber Optic Channel Links.

Link Verification Summary

Link verification ensures that a link meets IBM specifications, thereby allowing attachment of Fiber Optic Channel devices. Verifying a link requires using an optical source to transmit a signal through the link and a power meter to measure this signal at the other end. For multimode links, an optical mode conditioner (OMC) tool provides consistent power loss measurements.

Before you begin link verification, you need the following information:

- Link distance.
- Link bandwidth (multimode only).
- Link documentation, such as a link diagram, schematic, or blueprint, and link performance data, such as trunk cable data sheets or operational test results. Also, the customer must provide the necessary documentation and specifications for the premises and external trunk cables if installed.

You can also use the *Cable Administration Work Sheet,* SX23-0415, to record the required link information. Figure 5-4 on page 5-6 shows an example of a completed worksheet.

Link verification consists of (1) calibrating the test equipment, (2) obtaining reference levels, and (3) substituting a link cable for a test cable to obtain the loss measurements. This measured loss should be less than the maximum allowable link loss.

The amount of loss introduced by the link depends on the jumper cable length(s), the trunk cable length and specifications, and the number and type of link splices and connectors.

To perform link verification, follow the step-by-step procedures described in "Link Problem Determination Using MAPs" on page 3-3.

Chapter 3. Problem Determination Procedures

This chapter contains link problem determination that can be performed by using either the maintenance analysis procedures (MAPs) or the “fast-path” method. The procedure you use depends on the amount of guidance you require and the type of link you are servicing.

- Use the MAPs and follow the step-by-step instructions to perform link problem determination, link verification, and jumper cable verification.
- Use the fast-path method (see “Link Problem Determination Using the Fast-Path Method” on page 3-21) if you know how to perform Fiber Optic Channel link problem determination and do not want to use the MAPs, or if you are working on a coupling facility channel link.

Notes:

1. The MAPs use the optical mode conditioner (OMC) tool for multimode ESCON link measurements; the fast-path method does not.
2. The MAPs use the term *simplex* when referring to non-duplex connectors or connections such as ST, FC, or biconic. Most figures, however, show only biconic or duplex components.
3. Before beginning this section, network problem determination should have isolated the problem to a specific link and device maintenance procedures should have been completed.
4. An optical power meter reading LO indicates that no light has been detected by the meter. There are several possible causes for this condition:
   - A jumper cable is either unplugged or plugged in the wrong direction.
   - A jumper cable terminated with simplex connectors could be plugged as transmit-to-transmit and receive-to-receive instead of transmit-to-receive.
   - The entire link does not have an odd number of crossovers.
   - A link component is damaged and a connector or coupler has failed.

Start Link Problem Determination

During fiber optic channel link problem determination, the devices at each end of the link are identified as device 1 and device 2. Always refer to the device where you start these procedures as device 1.

Problem determination consists of measuring the link at specific points. These measured values are then compared to acceptable or maximum values to determine if the link loss is within specifications. Table 3-1 on page 3-4 and Table 3-2 on page 3-6 contain these values for the MAP procedures; Table E-2 on page E-6 contains the fast-path values. If it is determined that a device transmitter or receiver is not within specifications and the device is maintained by IBM, replace the transceiver card according to the device maintenance procedure and verify correct link operation. If the device is not maintained by IBM, inform the customer that the transceiver is out of specification and that this is the probable source of the error, then return to the IBM device that generated the call and follow its maintenance procedures for end of call. If the problem still exists after replacing the transceiver card, go to “MAP 0300: Start” on page 3-2 to perform link problem determination or verification.

Go to “MAP 0300: Start” on page 3-2 to perform link problem determination or verification.

MAP 0300: Start

001

Do you want to use the maintenance analysis procedures (MAPs) to perform link problem determination or verification?

Note: You must use the fast path procedures if you are working on coupling facility channel links.

If **yes** go to step 3. If **no**, continue with the next step.

002

Go to “Link Problem Determination Using the Fast-Path Method” on page 3-21

003

Go to “Link Problem Determination Using MAPs” on page 3-3

Link Problem Determination Using MAPs

Begin at “MAP 0310: Testing a Link” on page 3-7 to perform step-by-step problem determination or verification of a link segment or component. Before you begin, see “Common Link Failures” on page 2-6 for additional information.

Table 3-1. Maximum Link Loss With Optical Source Tool as a Transmitter (at 1300 nm)

Link/Fiber Type	Maximum Loss	Maximum Length	Trunk Size
ESCON			
Multimode	7.0 dB (Note 1)	2.0 km (1.24 miles)	62.5 µm
Multimode	6.5 dB (Note 1)	2.0 km (1.24 miles)	50.0 µm
Multimode	7.0 dB (Note 1)	3.0 km (1.86 miles)	62.5 µm
Single-mode	14.0 dB	20 km (12.4 miles)	9 to 10 µm
Coupling Facility Channel			
Multimode (discontinued May, 1998)	8.0 dB (Note 2)	1.0 km (0.62 miles)	50.0 µm
Single-mode 1.06 Gbit/s or 2.1 Gbit/s	7.0 dB	10 km (6.2 miles)	9 to 10 µm
Single-mode card with 50 micron optical mode conditioner over multimode fiber	5.0 dB	550 meters (0.34 miles)	50.0 µm
FDDI			
Multimode	9.0 dB	2.0 km (1.24 miles)	62.5 µm
ATM			
Multimode	11.0 dB	2.0 km (1.24 miles)	62.5 µm
Single-mode	15.0 dB	20.0 km (12.4 miles)	9 to 10 µm
FICON			
Multimode with 50 micron optical mode conditioner on an LX link	5.0 dB	550 meters (0.34 miles)	50.0 µm (Note 3)
Multimode with 62.5 micron optical mode conditioner on an LX link	5.0 dB	550 meters (0.34 miles)	62.5 µm (Note 3)
Single-mode LX 1gb	7.8 dB	10 km (6.2 miles)	9 to 10 µm
Single-mode LX 2gb	7.8 dB	10 km (6.2 miles)	9 to 10 µm
Multimode SX (160 MHz•Km) 1gb	2.76 dB	250 meters (0.16 miles)	62.5 µm
Multimode SX (160 MHz•Km) 2gb	1.98 dB	120 meters (0.07 miles)	62.5 µm
Multimode SX (200 MHz•Km)	3.0 dB	300 meters (0.19 miles)	62.5 µm
Multimode SX 1gb	3.85 dB	500 meters (0.31 miles)	50 µm
Multimode SX 2gb	2.62 dB	300 meters (0.19 miles)	50 µm
Gigabit Ethernet (GbE) LX			
Multimode with 50 micron optical mode conditioner	2.4 dB	550 meters (0.34 miles)	50 µm
Multimode with 62.5 micron optical mode conditioner	2.4 dB	550 meters (0.34 miles)	62.5 µm
Single-mode	4.6 dB	5 km (3.1 miles)	9 to 10 µm
Gigabit Ethernet (GbE) SX			
Multimode 50 micron	3.6 dB	550 meters (0.34 miles)	50 µm
Multimode 62.5 micron	2.6 dB	275 meters (0.17 miles)	62.5 µm

Notes:

1. This value does **not** include the higher-order-mode loss because the MAPs use the OMC tool for multimode link measurements.
2. Multimode coupling facility channel links operate at wavelengths of 770 - 850 nm; their maximum distance is 1 km (0.62 miles) using 50 micron fiber, with a maximum allowable loss of 3 dB/km measured at 850 nm.

3. The use of MCP cables is not supported over 1 gb.

Table 3-2. Maximum IBM Jumper Cable Attenuation (Including Connectors)

Fiber Type	Cable Length in Meters (ft.)	Maximum Loss
ESCON, ATM, FICON LX, FDDI, GbE LX		
Multimode	4 to 85 (12 to 279)	1.0 dB at 1300 nm
Multimode	86 to 143 (280 to 469)	1.1 dB at 1300 nm
Multimode	144 to 200 (470 to 656)	1.2 dB at 1300 nm
Multimode	201 to 257 (657 to 843)	1.3 dB at 1300 nm
Multimode	258 to 314 (844 to 1030)	1.4 dB at 1300 nm
Multimode	315 to 371 (1031 to 1217)	1.5 dB at 1300 nm
Multimode	372 to 428 (1218 to 1404)	1.6 dB at 1300 nm
Multimode	429 to 485 (1405 to 1591)	1.7 dB at 1300 nm
Multimode	486 to 500 (1592 to 1640)	1.75 dB at 1300 nm
Coupling facility channel, FICON SX, GbE SX		
Multimode	4 to 50 (12 to 164)	1.0 dB at 850 nm
Multimode	51 to 117 (165 to 384)	1.2 dB at 850 nm
Multimode	118 to 183 (385 to 600)	1.4 dB at 850 nm
Multimode	184 to 250 (601 to 820)	1.6 dB at 850 nm
Multimode	251 to 317 (821 to 1040)	1.8 dB at 850 nm
Multimode	318 to 383 (1041 to 1257)	2.0 dB at 850 nm
Multimode	384 to 450 (1258 to 1476)	2.2 dB at 850 nm
Multimode	451 to 500 (1476 to 1640)	2.35 dB at 850 nm
ESCON, coupling facility channel, ATM, FICON, GbE		
Single-mode	4 to 300 (12 to 984)	1.0 dB at 1300 nm
Single-mode	301 to 500 (985 to 1640)	1.1 dB at 1300 nm
Note: Use supplier attenuation values if jumpers are not supplied by IBM.		

MAP 0310: Testing a Link

001

1. Compare the configuration of the link you want to test to those shown on page 2-4; then select a work sheet from Appendix E, “Work Sheets,” on page E-1 that most resembles this configuration.
2. Go to Step 002.

002

1. Record the device 1 and device 2 identification information on the work sheet. **Remember that you are at device 1**.
2. Test both fibers in the link, starting with “MAP 0320: Testing Fiber 1” on page 3-8.

MAP 0320: Testing Fiber 1

001

Go to "Obtaining Reference Levels and Attaching Test Equipment to a Link" on page 3-27 to obtain **P1** and to attach the test equipment; then return here. The optical source and attached test equipment should now be connected to the device 1 end, and the power meter and attached test equipment to the device 2 end. Go to step Step 002.

002

1. Record the values for **P1** and **L** in the ***Fiber 1*** column on the work sheet:

   P1 = the reference level from the applicable procedure in "Obtaining Reference Levels and Attaching Test Equipment to a Link" on page 3-27

   L = the maximum link loss value from Table 3-1 on page 3-4.
2. Calculate the minimum acceptable receive level **F1**, and record the value in the ***Fiber 1*** column on the work sheet. See the example below, and go to step Step 003.

Example:

			Multimode	**Single-Mode**
P1	Reference level		-21.0 dBm	-10.0 dBm
L	Maximum link loss	**(-)**	7.0 dB	14.0 dB
F1	Minimum acceptable receive level at **A1**		-28.0 dBm	-24.0 dBm

003

Observe the power meter display, and go to step Step 004.

004

Is the meter reading at A1 less than the minimum acceptable receive level F1 ? (Example: -32.0 dBm is less than -29.0 dBm.)

If **yes** go to step 6. If **no** continue with next step.

005

Fiber 1 loss is within specifications. Fiber 2 must now be tested. Go to “MAP 0340: Testing Fiber 2” on page 3-13.

006

Fiber 1 loss is **not** within specifications. Go to step Step 007.

007

Does this link configuration consist of only 1 jumper cable?

If **yes** go to step 11. If **no** continue with next step.

008

Take the power meter and attached test equipment to C1 .
Is jumper 1 duplex-to-duplex?

If **yes**, go to step 10. If **no**, continue with next step.

009

Go to “Obtaining P2 for a Multimode Link” on page 3-33. Record the P2 value in the area labeled Px in the ***Fiber 1*** column on the work sheet; then go to “MAP 0330: Fiber 1 Loss Unacceptable” on page 3-10.

010

Record the value P1 in the area labeled Px in the ***Fiber 1*** column on the work sheet; then go to “MAP 0330: Fiber 1 Loss Unacceptable” on page 3-10.

011

Replace the jumper cable, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

MAP 0330: Fiber 1 Loss Unacceptable

001

You are here because:
The receive level for fiber 1 is less than the minimum acceptable receive level. Possible causes could be a:
- Loose or dirty connector
- Cut or damaged jumper cable or trunk cable
- Defective adapter, coupler, or distribution panel

1. The value **P1** or **P2** obtained in the reference level procedure should have been recorded in the area labeled **Px** in the ***Fiber 1*** column on the work sheet.
2. Obtain the maximum jumper cable dB loss values for both jumper 1 and jumper 2 from Table 3-2 on page 3-6. Record these values in the areas labeled **J1** and **J2** in the ***Fiber 1*** column on the work sheet as required for your configuration.
3. Calculate the minimum acceptable receive level **G1**, and record this value in the ***Fiber 1*** column on the work sheet. See the example below, and go to step 2.

Example:

			Multimode	Single-Mode
Px	Reference level		-20.2 dBm	-10.0 dBm
J1	Maximum jumper loss	(-)	1.2 dB	1.1 dB
G1	Minimum acceptable receive level at **C1**		-21.4 dBm	-11.1 dBm

002

1. If disconnected in a previous step, connect the optical source and attached test equipment to jumper 1 at **B1**.
2. Disconnect jumper 1 from the distribution panel at **C1**. If jumper 1 has simplex connectors, remove **only** the black-coded connector from the distribution panel.
3. Connect the power meter and attached test equipment to jumper 1 at **C1**. If jumper 1 has simplex connectors, attach the black-coded connector to the test equipment.
4. Observe the power meter display, and go to Step 003 on page 3-11.

003

Is the meter reading at C1 less than the minimum acceptable receive level G1 ? (Example: -22.5 dBm is less than -21.4 dBm.)

If **yes**, go to Step 007. If **no**, go to Step 004.

004

Does this configuration consist of 2 jumper cables and 1 distribution panel (no trunk)?

If **yes**, go to Step 006. If **no**, go to Step 005.

005

1. Disconnect the power meter and attached test equipment from jumper 1 at C1 .
2. Reconnect jumper 1 to the distribution panel at C1 .
3. Disconnect the optical source and attached test equipment from B1 .
4. Take the optical source, power meter, and all attached test equipment to D1 ; then go to Step 008.

006

Jumper 2 loss is **not** within specifications. Replace jumper 2, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

007

Jumper 1 loss is **not** within specifications. Replace jumper 1, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

008

Is jumper 2 duplex-to-duplex?

If **yes** go to Step 010. If **no** go to Step 009

009

Go to “Obtaining Reference Levels and Attaching Test Equipment to a Link” on page 3-27, and obtain P3 . Record this value in the area labeled Py in the ***Fiber 1*** column on the work sheet; then go to Step 011 on page 3-12.

010

Record the value P1 in the area labeled Py in the ***Fiber 1*** column on the work sheet; then go to Step 011 on page 3-12.

011

Calculate the minimum acceptable receive level **H1** , and record the value in the ***Fiber 1*** column on the work sheet. See the example below, and go to Step 012.

Example:

			Multimode	**Single-Mode**
Py	Reference level		-20.0 dBm	-10.0 dBm
J2	Maximum jumper loss	**(-)**	1.2 dB	1.1 dB
H1	Minimum acceptable receive level at **A1**		-21.2 dBm	-11.1 dBm

012

1. Disconnect jumper 2 from the distribution panel at **D1** . If jumper 2 has simplex connectors, remove **only** the white-coded connector.
2. Connect the optical source and attached test equipment to jumper 2 at **D1** . If jumper 2 has simplex connectors, attach the white-coded connector to the test equipment.
3. Take the power meter and attached test equipment to **A1** ; then connect it to jumper 2.
4. Observe the power meter display, and go to Step 013.

013

Is the meter reading at A1 less than the minimum acceptable receive level H1 ? (Example: -25.0 dBm is less than -21.2 dBm.)

If **yes**, go to Step 015. If **no**, go to Step 014.

014

The problem is in the trunk or distribution panel(s). If this link segment includes:

- Fiber Transport Services (FTS) components, contact your local Availability Services Marketing Specialist.
- Components covered by another service agreement or maintenance offering, contact the IBM marketing representative
- Components not covered by any service agreement or maintenance offering, inform the customer

015

Jumper 2 loss is **not** within specifications. Replace jumper 2, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

MAP 0340: Testing Fiber 2

001

Note: When using this MAP, the optical source and attached test equipment should be connected to the device 2 end, and the power meter and attached test equipment should be connected to the device 1 end.

Have you obtained P1 and not switched off power to the optical source?

If **yes**, go to Step 003. If **no**, go to Step 002.

002

Go to "Obtaining Reference Levels and Attaching Test Equipment to a Link" on page 3-27 to obtain P1 , and attach the test equipment; then go to step Step 004.

003

Go to step Step 004.

004

Make sure the optical source and attached test equipment are connected at the device 2 end, and the power meter and attached test equipment are connected at the device 1 end.

1. Record the values for P1 and L in the ***Fiber 2*** column on the work sheet:

   P1 = the reference level from the applicable procedure in "Obtaining Reference Levels and Attaching Test Equipment to a Link" on page 3-27

   L = the maximum link loss value from Table 3-1 on page 3-4.
2. Calculate the minimum acceptable receive level F2 , and record the value in the ***Fiber 2*** column on the work sheet. See the example below, and go to step Step 005.

Example:

			Multimode	**Single-Mode**
P1	Reference level		-21.0 dBm	-10.0 dBm
L	Maximum link loss		7.0 dB	14.0 dB
		(-)	___________	___________
F2	Minimum acceptable receive level at A2		-28.0 dBm	-24.0 dBm

---

005

Observe the power meter display, and go to Step 006 on page 3-14.

006

Is the meter reading at A2 less than the minimum acceptable receive level F2 ? (Example: -32.0 dBm is less than -29.0 dBm.)

If **yes**, go to Step 008. If **no**, go to Step 007.

007

Fiber 2 loss is within specifications. If you have already tested fiber 1, the test procedure is complete. Return to the procedure that directed you here. If the problem still exists, contact your next level of support.

008

Fiber 2 loss is **not** within specifications. Go to step Step 009.

009

Does this link configuration consist of only 1 jumper cable?

If **yes**, go to Step 013. If **no**, go to Step 010.

010

Take the power meter and attached test equipment to D2 .

Is jumper 2 duplex-to-duplex?

If **yes**, go to Step 012. If **no**, go to Step 011.

011

Go to “Obtaining P2 for a Multimode Link” on page 3-33. Record the P2 value in the area labeled Px in the ***Fiber 2*** column on the work sheet; then go to “MAP 0350: Fiber 2 Loss Unacceptable” on page 3-15.

012

Record the value P1 in the area labeled Px in the ***Fiber 2*** column on the work sheet; then go to “MAP 0350: Fiber 2 Loss Unacceptable” on page 3-15.

013

Replace the jumper cable, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

MAP 0350: Fiber 2 Loss Unacceptable

001

You are here because:
The receive level for fiber 2 is less than the minimum acceptable receive level. Possible causes could be a:
- Loose or dirty connector
- Cut or damaged jumper cable or trunk cable
- Defective adapter, coupler, or distribution panel

1. The value **P1** or **P2** obtained in the reference level procedure should have been recorded in the area labeled **Px** in the ***Fiber 2*** column on the work sheet.
2. Obtain the maximum jumper cable dB loss values for both jumper 2 and jumper 1 from Table 3-2 on page 3-6. Record these values in the areas labeled **J2** and **J1** in the ***Fiber 2*** column on the work sheet as required for your configuration.
3. Calculate the minimum acceptable receive level **G2**, and record this value in the ***Fiber 2*** column on the work sheet. See the example below, and go to step Step 002.

Example:

			Multimode	**Single-Mode**
Px	Reference level		-21.5 dBm	-10.0 dBm
J2	Maximum jumper loss	**(-)**	1.4 dB	1.1 dB
G2	Minimum acceptable receive level at **D2**		-22.9 dBm	-11.1 dBm

002

1. If disconnected in a previous step, connect the optical source and attached test equipment to jumper 2 at **B2**.
2. Disconnect jumper 2 from the distribution panel at **D2**. If jumper 2 has simplex connectors, remove **only** the black-coded connector from the distribution panel.
3. Connect the power meter and attached test equipment to jumper 2 at **D2**. If jumper 2 has simplex connectors, attach the black-coded connector to the test equipment.
4. Observe the power meter display, and go to step Step 003.

003

Is the meter reading at D2 less than the minimum acceptable receive level G2 ? (Example: -30.5 dBm is less than -22.9 dBm.)

If **yes**, go to Step 007. If **no**, go to Step 004.

004

Does this configuration consist of 2 jumper cables and 1 distribution panel (no trunk)?

If **yes**, go to Step 006. If **no**, go to Step 005.

005

1. Disconnect the power meter and attached test equipment from jumper 2 at D2 .
2. Reconnect jumper 2 to the distribution panel at D2 .
3. Disconnect the optical source and attached test equipment from B2 .
4. Take the optical source, power meter, and all attached test equipment to C2 ; then go to step Step 008.

006

Jumper 1 loss is **not** within specifications. Replace jumper 1, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

007

Jumper 2 loss is **not** within specifications. Replace jumper 2, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

008

Is jumper 1 duplex-to-duplex?

If **yes**, go to Step 010. If **no**, go to Step 009.

009

Go to “Obtaining Reference Levels and Attaching Test Equipment to a Link” on page 3-27, and obtain P3 . Record this value in the area labeled Py in the ***Fiber 2*** column on the work sheet; then go to step Step 011.

010

Record the value P1 in the area labeled Py in the ***Fiber 2*** column on the work sheet; then go to step Step 011.

011

Calculate the minimum acceptable receive level **H2** , and record the value in the ***Fiber 2*** column on the work sheet. See the example below, and go to step Step 012.

Example:

			Multimode	Single-Mode
Py	Reference level		-20.0 dBm	-10.0 dBm
J1	Maximum jumper loss	(-)	1.2 dB	1.1 dB
H2	Minimum acceptable receive level at **A2**		-21.2 dBm	-11.1 dBm

012

1. Disconnect jumper 1 from the distribution panel at **C2** . If jumper 1 has simplex connectors, remove **only** the white-coded connector.
2. Connect the optical source and attached test equipment to jumper 1 at **C2** . If jumper 1 has simplex connectors, attach the white-coded connector to the test equipment.
3. Take the power meter and attached test equipment to **A2** ; then connect it to jumper 1.
4. Observe the power meter display, and go to step Step 013.

013

Is the meter reading at A2 less than the minimum acceptable receive level H2 ? (Example: -25.0 dBm is less than -21.2 dBm.)

If **yes**, go to Step 015. If **no**, go to Step 014.

014

The problem is in the trunk or distribution panel(s). If this link segment includes:

- Fiber Transport Services (FTS) components, contact your local Availability Services Marketing Specialist.
- Components covered by another service agreement or maintenance offering, contact the IBM marketing representative
- Components not covered by any service agreement or maintenance offering, inform the customer

015

Jumper 1 loss is **not** within specifications. Replace jumper 1, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

MAP 0360: Jumper Cable Verification

001

You are here because:
The fast-path procedure directed you to verify the loss of a jumper cable.

Obtaining the reference level:

1. Go to “Obtaining Reference Levels and Attaching Test Equipment to a Link” on page 3-27, and obtain the level (**P1** , **P2** , or **P3**) that matches the cable configuration and direction of light propagation for the fiber being tested. **If obtaining P1 , do not attach the test equipment to the link.**
2. Go to step Step 002.

002

Measuring the jumper loss:

1. Connect the jumper cable that you want to verify to the couplers; then observe the power meter display.
2. The difference between the meter reading and the reference level must not exceed the maximum jumper loss found in Table 3-2 on page 3-6. See the example below, and go to Step 003 on page 3-19.

Example:

		Multimode	**Single-Mode**
Reference level		-21.0 dBm	-12.0 dBm
Meter reading		-25.0 dBm	-15.0 dBm
	(-)	___________	___________
Jumper loss		4.0 dB	3.0 dB

003

Is the jumper loss greater than the maximum jumper loss value?

If **yes**, go to Step 005. If **no**, go to Step 004.

004

The fiber is within specifications.

- If you need to verify the second fiber in the jumper cable, go to Step 006.
- If not, return to the fast-path procedure, and continue with the next step.

005

The jumper is **not** within specifications. Replace the jumper, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

006

Verifying the second fiber in the jumper cable:

1. Go to "Obtaining Reference Levels and Attaching Test Equipment to a Link" on page 3-27, and obtain the level (**P1** , **P2** , or **P3**) that matches the cable configuration and direction of light propagation for the fiber being tested. **If obtaining P1 , do not attach the test equipment to the link.**
2. Move the optical source and the power meter to the jumper cable ends opposite their previous attachment in step Step 002.
3. Reconnect both ends of the jumper cable to the couplers; then observe the power meter display.
4. The difference between the meter reading and the reference level must not be greater than the maximum jumper loss found in Table 3-2 on page 3-6. See the example below, and go to Step 007 on page 3-20.

Example:

		Multimode	Single-Mode
Reference level		-21.0 dBm	-12.0 dBm
Meter reading		-25.0 dBm	-15.0 dBm
	(-)	___________	___________
Jumper loss		4.0 dB	3.0 dB

007

Is the jumper loss greater than the maximum jumper loss value?

If **yes**, go to Step 009. If **no**, go to Step 008.

008

The jumper is within specifications. Jumper cable verification is complete. Return to the fast-path procedure, and continue with the next step.

009

The jumper is **not** within specifications. Replace the jumper cable, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

Link Problem Determination Using the Fast-Path Method

Use this method to isolate a failing link by either excluding (swapping) each link segment or by measuring optical power through each of the 2 fibers. See also "Common Link Failures" on page 2-6 for additional information. If you cannot determine the problem using this method, contact your next level of support.

Note: Before you begin, make a copy of the "Fast Path Work Sheet: All Link Configurations" on page E-4. You will use this work sheet to record the optical power levels at specific points in the link, and then determine where the failure exists.

Note: Although the procedures refer only to IBM duplex and biconic connectors and components, they can also be performed using ST, FC, MT–RJ, LC, and FICON connector types. The optical source tool can only be used on links with a wavelength of 1300 µm; links operating at other wavelengths (such as SX links at 850 nm or wavelength multiplexed links near 1550 nm) must use the attached device as a light source. As a rule of thumb, typical optical fiber loss at 1300 µm is 0.5dB/km; at 850 nm is 3dB/km; and at 1550 nm is 0.3dB/km.

1. Have you already obtained the transmit and receive levels for both devices (device 1 and device 2)?
   - If **Yes**, record the values on the fast-path work sheet as **B1** (device 1 transmit), **A2** (device 1 receive), **B2** (device 2 transmit), and **A1** (device 2 receive).
   - If **No**, go to Appendix C, "Measuring Device Transmit and Receive Levels," on page C-1 to obtain them. Record these values on your fast-path work sheet; then return here when done.
2. Use the work sheet to calculate if the loss of either of the 2 link fibers exceeds the maximum link loss shown in Table E-1 on page E-4.
   a. If **both** fibers **are** within specifications, either return to the maintenance procedures that directed you here or contact your next level of support.
   b. If **1** or **both** fibers **are not** within specifications, and the link consists of only 1 jumper cable, replace the jumper cable.
   c. If the link has more than 1 jumper cable or has both jumper and trunk cables, you must isolate one segment of the link at a time until you locate the failure. See also any previous link loss data for comparison, including the installer's records if available.
      1) If you want to exclude each link segment, go to step 3.
      2) If you want to measure each link segment, go to step 4.

3. To exclude a link segment, use:
   - A spare link
   - A spare pair of trunk fibers
   - A spare jumper cable
   - A spare coupler or adapter
4. To measure a link segment, first refer to the work sheet. You should have already determined if fiber 1 or fiber 2 is not within specifications. This determines the points within the link that you should measure. You also need to know the length of the jumper cable(s) to determine if the power level at these points is within specifications. See also “Determining the Direction of Light Propagation” on page 2-7 if necessary.

   If you are measuring a link in a coupling facility with open fiber control, you can only isolate link segments using the splitter tool; see “Isolating Link Segments Using the Splitter Tool” on page C-20.

   a. If fiber 1 **is not** within specifications (**B1** to **A1**):
      1) Take measurements at **C1** and **D1** . Measure **C1** at the jumper 1 connector (removed from the distribution panel), and measure **D1** at the distribution panel.
         For ESCON links:
         – Multimode links–See Figure 3-1 and Figure 3-2 on page 3-23.
         – Single-mode links–See Figure 3-3 and Figure 3-4 on page 3-24.
         For coupling facility links use a splitter tool to isolate a link segment:
         – Multimode links–See Figure 3-7 on page 3-26.
         – Single-mode links–See Figure 3-8 on page 3-26.
         – FDDI links, see Figure 3-5 on page 3-25.
         – ATM, FICON, or GbE links, see Figure 3-6 on page 3-25.
         For more information on the splitter tools, see “Isolating Link Segments Using the Splitter Tool” on page C-20.
      2) Is the power level at **C1** **less** than the value shown in Table E-2 on page E-6 (use the jumper 1 cable length)?
         - If **Yes**, jumper 1 could be defective. Verify the jumper cable loss before replacing the cable. Go to “MAP 0360: Jumper Cable Verification” on page 3-18.
         - If **No**, go to the next step.
      3) Is the power level at **D1** **greater** than the value shown in Table E-2 on page E-6 (use the jumper 2 cable length)?
         - If **Yes**, jumper 2 could be defective. Verify the jumper cable loss before replacing the cable. Go to “MAP 0360: Jumper Cable Verification” on page 3-18.
         - If **No**, go to step 5.
   b. If fiber 2 **is not** within specifications (**B2** to **A2**):
      1) Take measurements at **C2** and **D2** . Measure **C2** at the distribution panel, and measure **D2** at the jumper 2 connector (removed from the distribution panel). See Figure 3-1 and Figure 3-2 on page 3-23 for multimode links; see Figure 3-3 and Figure 3-4 on page 3-24 for single-mode links.
      2) Is the power level at **D2** **less** than the value shown in Table E-2 on page E-6 (use the jumper 2 cable length)?
         - If **Yes**, jumper 2 could be defective. Verify the jumper cable loss before replacing the cable. Go to “MAP 0360: Jumper Cable Verification” on page 3-18.
         - If **No**, go to the next step.

3) Is the power level at **C2** **greater** than the value shown in Table E-2 on page E-6 (use the jumper 1 cable length)?
   - If **Yes**, jumper 1 could be defective. Verify the jumper cable loss before replacing the cable. Go to “MAP 0360: Jumper Cable Verification” on page 3-18.
   - If **No**, go to step 5.

5. The trunk cable is the most probable cause of the failure. Switch to an alternate pair of trunk fibers (if available), and inform the customer. If the problem still exists, contact your next level of support

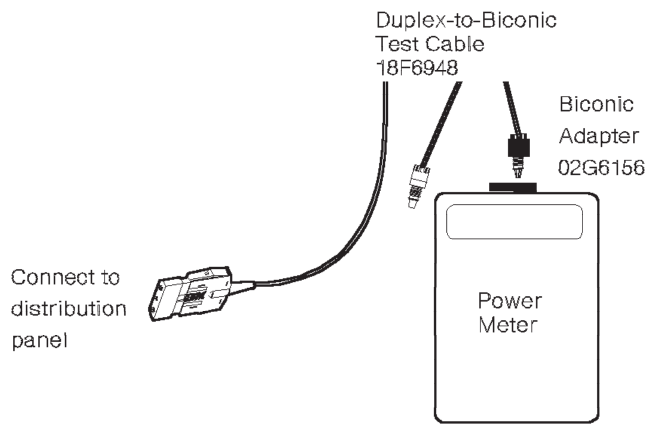


Figure 3-1. Measuring **C2** *or* **D1** *for a Multimode Link*

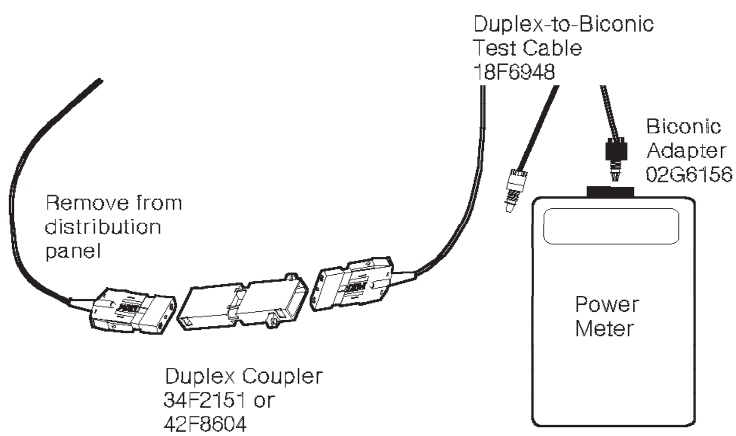


Figure 3-2. Measuring **C1** *or* **D2** *for a Multimode Link*

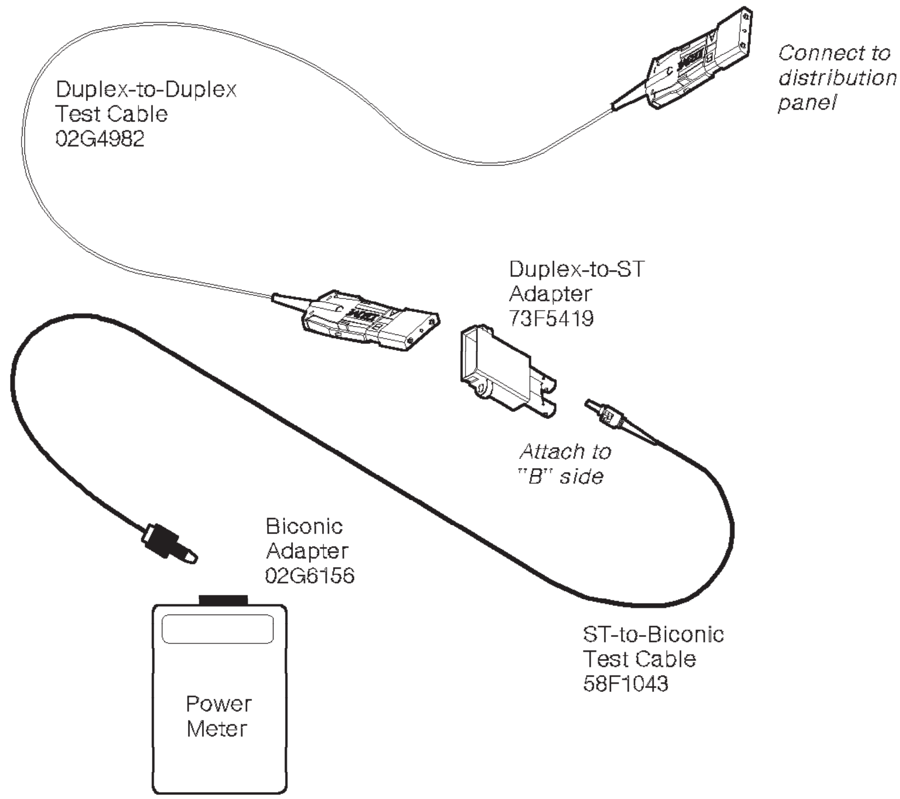


Figure 3-3. Measuring **C2** *or* **D1** *for a Single-Mode Link*

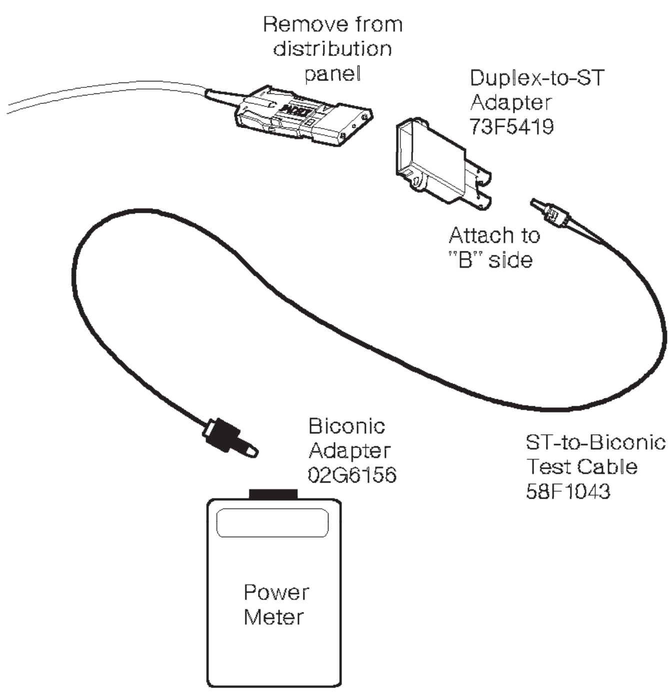


Figure 3-4. Measuring **C1** *or* **D2** *for a Single-Mode Link*

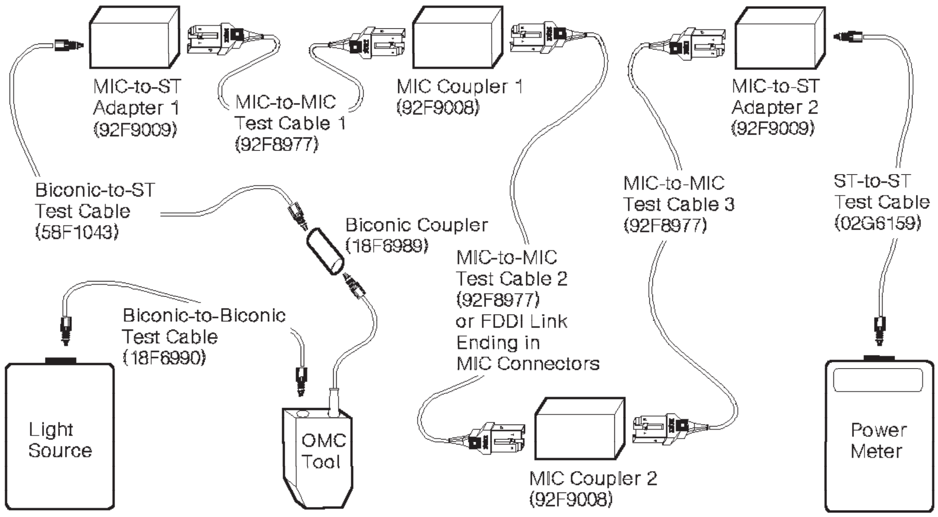


Figure 3-5. Obtaining the FDDI End-to-End Link Loss Using the Fast-Path Method

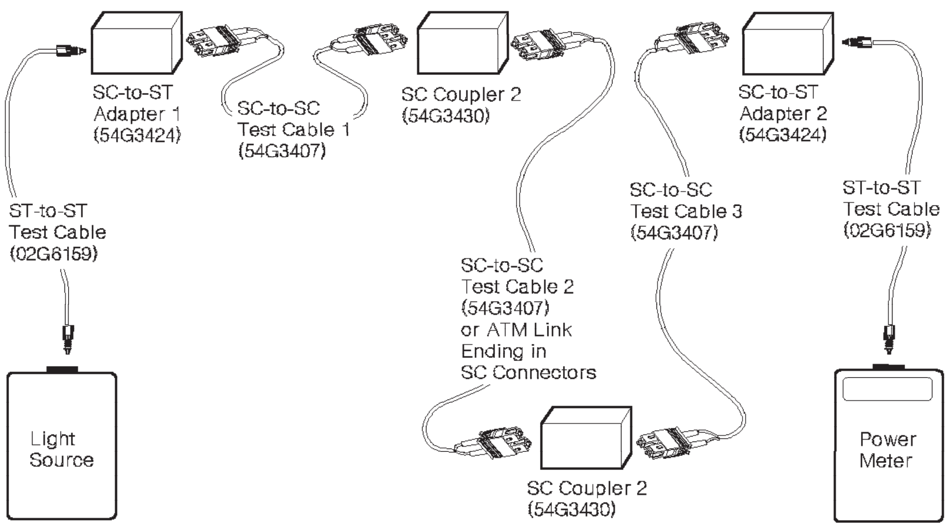
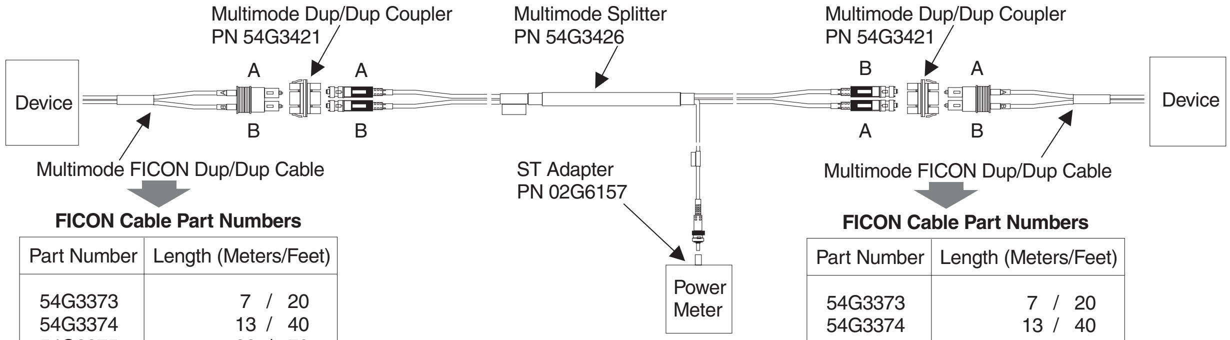


Figure 3-6. Obtaining the ATM End-to-End Link Loss Using the Fast-Path Method



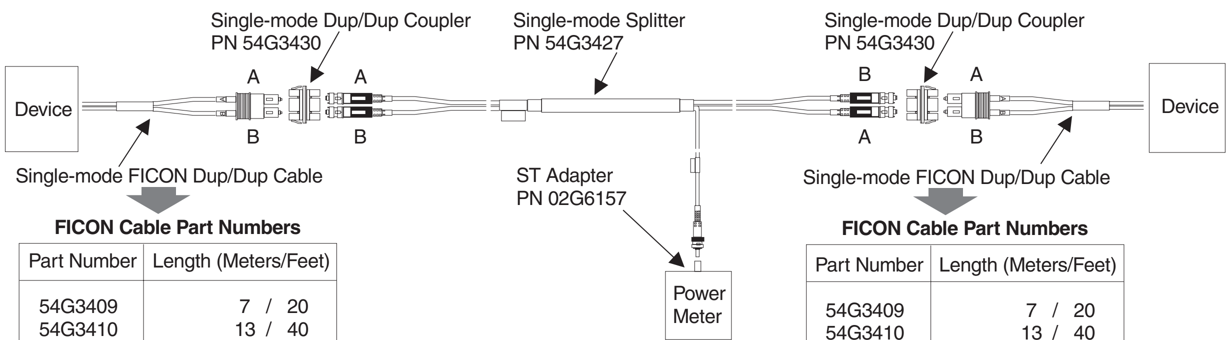
FICON Cable Part Numbers

Part Number	Length (Meters/Feet)
54G3373	7 / 20
54G3374	13 / 40
54G3375	22 / 70
54G3376	31 / 100
54G3377	46 / 150
54G3378	61 / 200
54G3379	Custom

FICON Cable Part Numbers

Part Number	Length (Meters/Feet)
54G3373	7 / 20
54G3374	13 / 40
54G3375	22 / 70
54G3376	31 / 100
54G3377	46 / 150
54G3378	61 / 200
54G3379	Custom

Figure 3-7. Isolating a Multimode Link Segment with a Splitter Tool



FICON Cable Part Numbers

Part Number	Length (Meters/Feet)
54G3409	7 / 20
54G3410	13 / 40
54G3411	22 / 70
54G3412	31 / 100
54G3413	46 / 150
54G3414	61 / 200
54G3415	Custom

FICON Cable Part Numbers

Part Number	Length (Meters/Feet)
54G3409	7 / 20
54G3410	13 / 40
54G3411	22 / 70
54G3412	31 / 100
54G3413	46 / 150
54G3414	61 / 200
54G3415	Custom

Figure 3-8. Isolating a Single-Mode Link Segment with a Splitter Tool

Obtaining Reference Levels and Attaching Test Equipment to a Link

These procedures:

- Make sure the test equipment is calibrated.
- Provide instructions to obtain optical power reference levels for the problem determination procedures.
- Describe how to attach the calibrated test equipment to a link.

The figures used as examples in these procedures show the IBM part numbers of the test equipment. See Appendix B, “Tools, Test Equipment, and Parts,” on page B-1 for the part numbers of all test equipment.

Notes:

1. There are separate procedures for multimode and single-mode links and for links at different operating wavelengths. Make sure you are using the correct procedure.
2. The configuration chosen for a reference measurement should match the configuration of the link or jumper cable under test.
3. Only the multimode procedures for long wave (1300 µm) links use the OMC tool; multimode links for short wave (850 µm) links may use the same procedures as singlemode links.
4. Although the multimode procedures refer only to duplex and biconic connectors and components, they can also be performed using ST, FC, or FICON SC connector types.

P0 is the base measurement used to calibrate the power meter. It is also used as a reference for the other test configurations to make sure the test cables are operating within specifications. See “Obtaining **P0** for a Multimode Link” on page 3-28 or “Obtaining **P0** for a Single-Mode Link” on page 3-37.

Note: If unusual or unexpected readings occur while measuring power levels, verify that the **P0** value has not changed by more than 0.3 dB. If it has, clean the cable connectors and test equipment connections; then retry the test. If the problem still exists, replace the cable, the optical source, then the OMC tool (if applicable), and finally the power meter with known operational components.

P1 is the reference measurement used for end-to-end link problem determination. It is also used as a reference for jumper cable measurements when both ends of the jumper cable have duplex connectors. See “Obtaining **P1** and Attaching Test Equipment to a Multimode Link” on page 3-30 or “Obtaining P1 and Attaching Test Equipment to a Single-Mode Link” on page 3-38.

P2 and **P3**, used for long wavelength multimode only, are the reference measurements that apply when testing a duplex-to-biconic jumper cable. See “Obtaining **P2** for a Multimode Link” on page 3-33 and “Obtaining **P3** for a Multimode Link” on page 3-35.

After completing a reference measurement, leave the test cables and couplers plugged into the optical source and power meter. Then move the optical source, power meter, test cables, and couplers to the appropriate location, and plug them into the link cables. **If power to the optical source has been switched off, or if the test cables or couplers have been disconnected from the optical source or the power meter, repeat the reference measurement.**

Obtaining **P0** for a Multimode Link

This procedure applies only to ESCON or ATM long wavelengths links; other multimode laser links such as FICON SX or Gigabit Ethernet SX may use the same procedures as for singlemode fiber attachment. This procedure ensures proper operation of the optical source and the power meter, and establishes the power output of the optical source. If you require detailed operating instructions for the test equipment, refer to the manufacturer's operating manuals. The IBM Fiber Optic Field Test Support Kits (see Appendix B, "Tools, Test Equipment, and Parts," on page B-1) provide space for these manuals.

1. Make sure 1) the connectors are clean, 2) the LED module "plug-in" is inserted into the optical source, and 3) the biconic adapter is inserted into the power meter.
2. Switch on both instruments, and allow approximately 5 minutes for warm-up.

   Note: Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.
3. Set the power meter to 1300 nm.
4. Zero the power meter with darkened sensor.
5. Attach one end of a biconic-to-biconic test cable to the optical source; then attach the other end to the receptacle on the OMC tool (see Figure 3-9 on page 3-29).
6. Attach the biconic cable from the OMC tool to the power meter.
7. Adjust the optical source output to obtain a reading of -25.0 dBm (±1.0 dB) on the power meter display.
   - If the reading **is** within specifications, record this value as **P0** on the work sheet selected from Appendix E, "Work Sheets," on page E-1 for the fiber being tested; then go to "Obtaining **P1** and Attaching Test Equipment to a Multimode Link" on page 3-30. Do not disconnect the OMC tool, and do not switch off power to the optical source.
   - If the reading **is not** within specifications, remove the OMC tool, and connect the biconic-to-biconic test cable directly to the power meter. Adjust the optical source output to obtain -15.0 dBm (±1.0 dB) on the power meter.
     – If the reading **is** within specifications, reconnect the biconic-to-biconic test cable to the OMC tool, and reconnect the OMC tool to the power meter. If the power meter reads -25.0 dBm (±5.0 dB), adjust the optical source to obtain -25.0 dBm (±1.0 dB). If the optical source cannot be adjusted, replace the OMC tool.

– If the reading **is not** within specifications, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace the cable, then the optical source, and finally the power meter with known operational components.

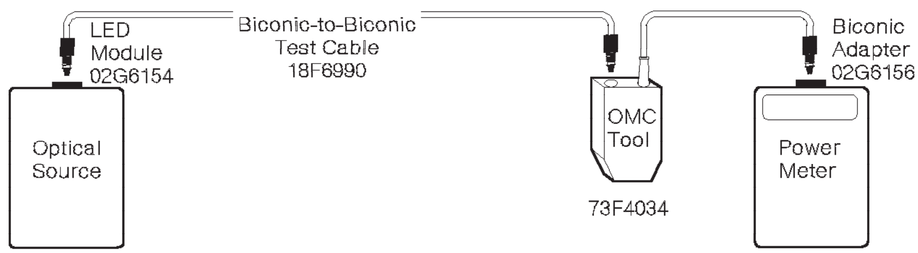


Figure 3-9. Obtaining **P0** *for a Multimode Link*

Obtaining P1 and Attaching Test Equipment to a Multimode Link

This procedure applies only to ESCON or ATM long wavelengths links; other multimode laser links such as FICON SX or Gigabit Ethernet SX may use the same procedures as for singlemode fiber attachment. This procedure checks the multimode test cables and establishes the power output of the optical source using these cables. It then shows how to attach this test equipment to a multimode link terminated by duplex connectors on both ends.

1. Obtain P0 if you have not already done so, or if power to the optical source has been switched off, or if the OMC tool has been disconnected from the optical source.
2. Make sure the LED module "plug-in" is inserted into the optical source, and the biconic adapter is inserted into the power meter.
3. Make sure all connectors are clean; then assemble the test equipment (see Figure 3-10 on page 3-31, Figure 3-12 on page 3-32, or Figure 3-13 on page 3-32).
   a. Remove the cable from the OMC tool to the power meter, and attach it to a biconic coupler.
   b. Attach the white-coded biconic connector of duplex-to-biconic test cable 1 to the other end of the biconic coupler; then attach the duplex connector to duplex coupler 1.
   c. Attach one end of a duplex-to-duplex test cable to duplex coupler 1; then attach the other end to duplex coupler 2.
   d. Attach the duplex connector of duplex-to-biconic test cable 2 to duplex coupler 2; then attach the black-coded biconic connector to the power meter.
4. Observe the power meter display. The maximum difference allowed between P1 and P0 is 2.5 dB.
   - If the difference is **less than** 2.5 dB, record the value as P1 on the work sheet selected from Appendix E, "Work Sheets," on page E-1 for the fiber being tested; then go to the next step.
   - If the difference is **greater** than 2.5 dB, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace each cable and then each coupler with known operational components until the test does not fail. If the test continues to fail, replace the OMC tool, then the optical source, and finally the power meter.
5. Remove the duplex-to-duplex test cable between the 2 duplex couplers. **Do not** switch off power to the optical source, and **do not** disconnect the test cables or couplers from the optical source or the power meter.
6. Attach the test equipment to the link as follows (see Figure 3-11 on page 3-31):
   a. Connect one end of the link to duplex coupler 1.
   b. Take the power meter and attached test equipment to the next point in the link you want to check; then connect that end to duplex coupler 2.

7. Return to the MAP that directed you here.

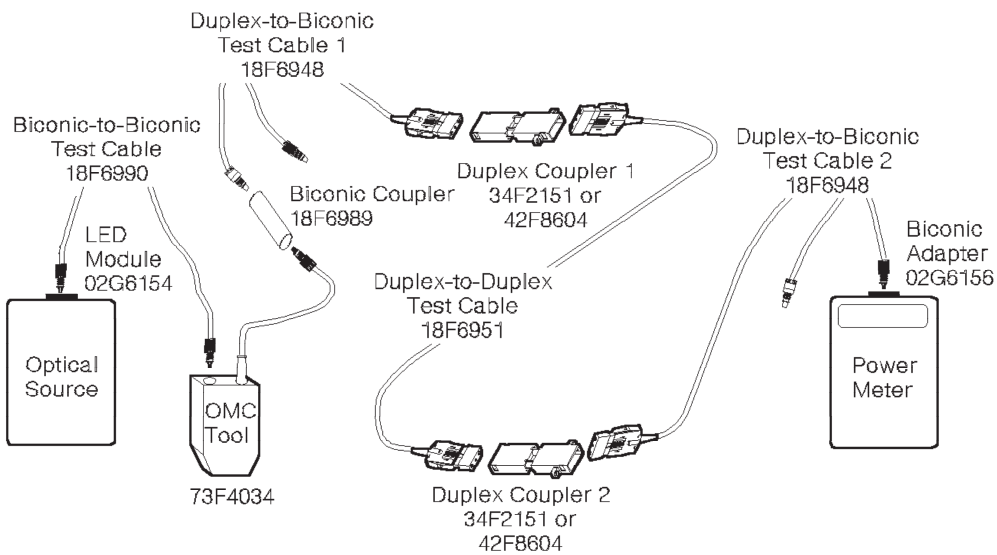


Figure 3-10. Obtaining **P1** *for a Multimode Link*

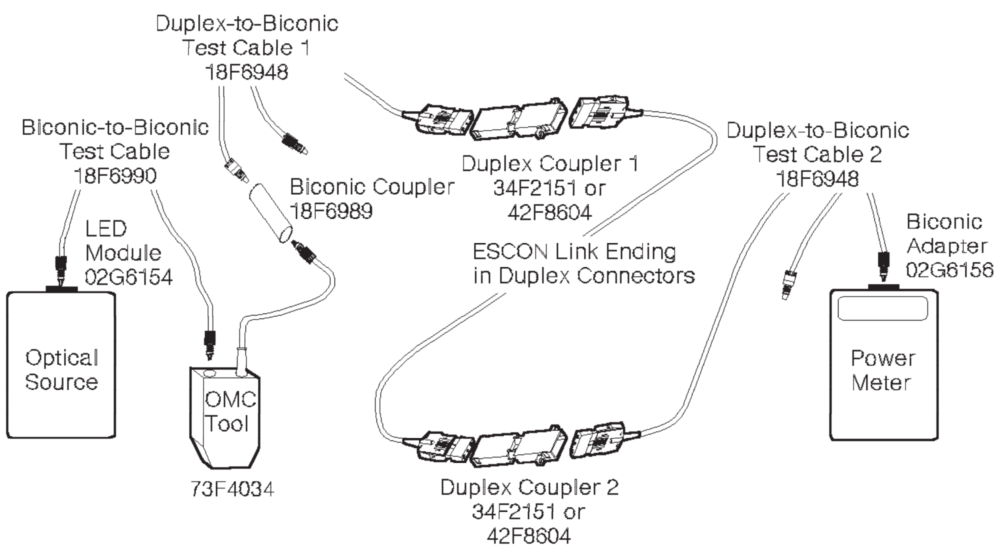


Figure 3-11. Connecting the Test Equipment to a Multimode Link

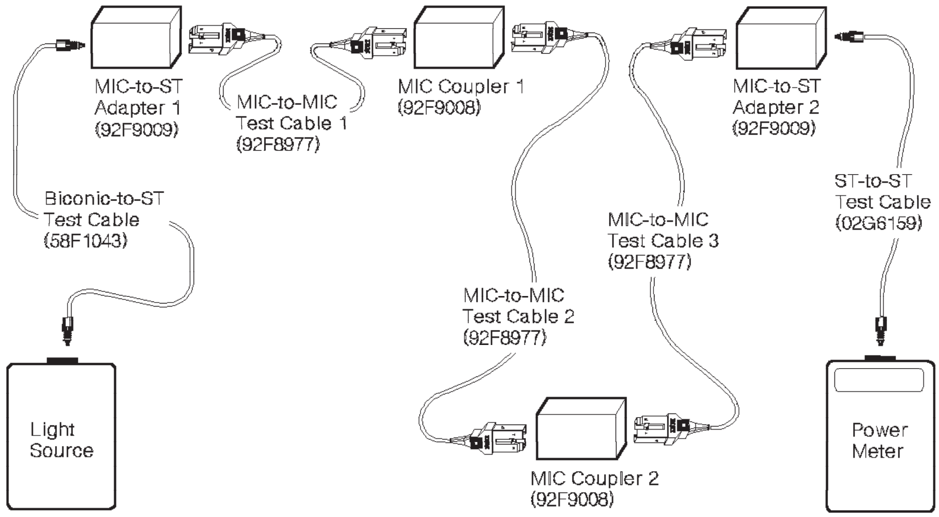


Figure 3-12. Obtaining the Link Loss Reference Level (P1) - FDDI

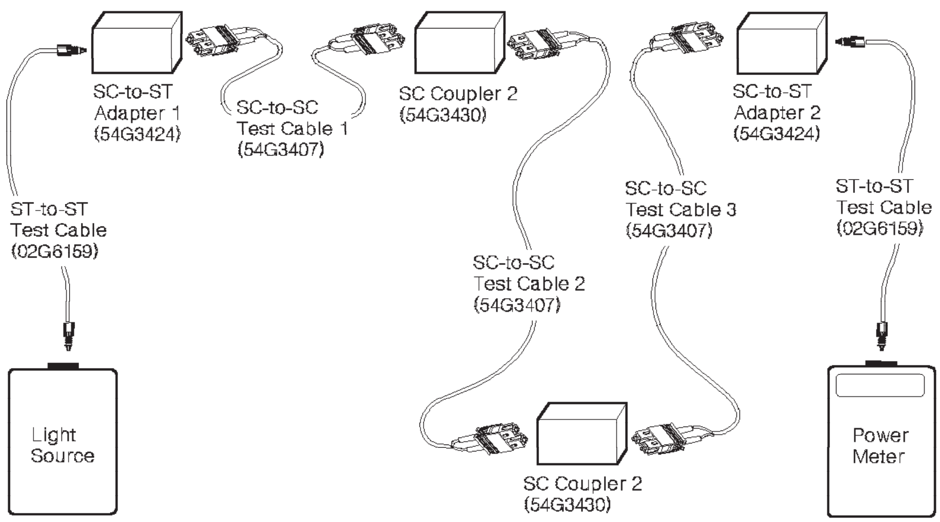


Figure 3-13. Obtaining the Link Loss Reference Level (P1) - ATM or FICON

Obtaining **P2** for a Multimode Link

Notes:
- Although this procedure refers only to duplex-to-biconic jumper cables, it also can be performed using IBM duplex-to-ST or duplex-to-FC cables and their associated adapters and couplers.
- If a step directs you to connect a test component that is already attached, continue with the next step.

This procedure applies only to ESCON or ATM long wavelengths links; other multimode laser links such as FICON SX or Gigabit Ethernet SX may use the same procedures as for singlemode fiber attachment.

P2 is used as a reference level for a duplex-to-biconic jumper cable when the direction of light propagation is from the optical source into the duplex connector and out of the biconic connector into the power meter.

1. Obtain **P0** if you have not already done so, or if power to the optical source has been switched off.
2. Make sure all connectors are clean; then assemble the components (see Figure 3-14 on page 3-34).
   a. Attach one end of a biconic-to-biconic test cable to the optical source; then attach the other end to the OMC tool.
   b. Attach the cable from the OMC tool to one end of biconic coupler 1.
   c. Attach the white-coded biconic connector of a duplex-to-biconic test cable to the other end of biconic coupler 1; then attach the duplex connector to the duplex coupler.
   d. Attach the duplex connector of a duplex-to-biconic test cable to the other end of the duplex coupler; then attach the black-coded biconic connector to biconic coupler 2.
   e. Attach one end of biconic-to-biconic test cable 2 to biconic coupler 2; then attach the other end to the power meter.
3. Observe the power meter display. The maximum difference allowed between **P2** and **P0** is 2.5 dB.
   - If the difference is **less** than 2.5 dB, record the value **P2** on the work sheet selected from Appendix E, "Work Sheets," on page E-1 in the area labeled **Px** for the fiber being tested; then go to the next step.
   - If the difference is **greater** than 2.5 dB, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace each cable and then each coupler with known operational components until the test does not fail. If the test continues to fail, replace the OMC tool, then the optical source, and finally the power meter.
4. Remove duplex-to-biconic test cable 2 (between the duplex coupler and biconic coupler 2) from the test equipment setup. **Do not** switch off power to the optical source, and **do not** disconnect the test cables or couplers from the optical source or the power meter.
5. Return to the MAP that directed you here.

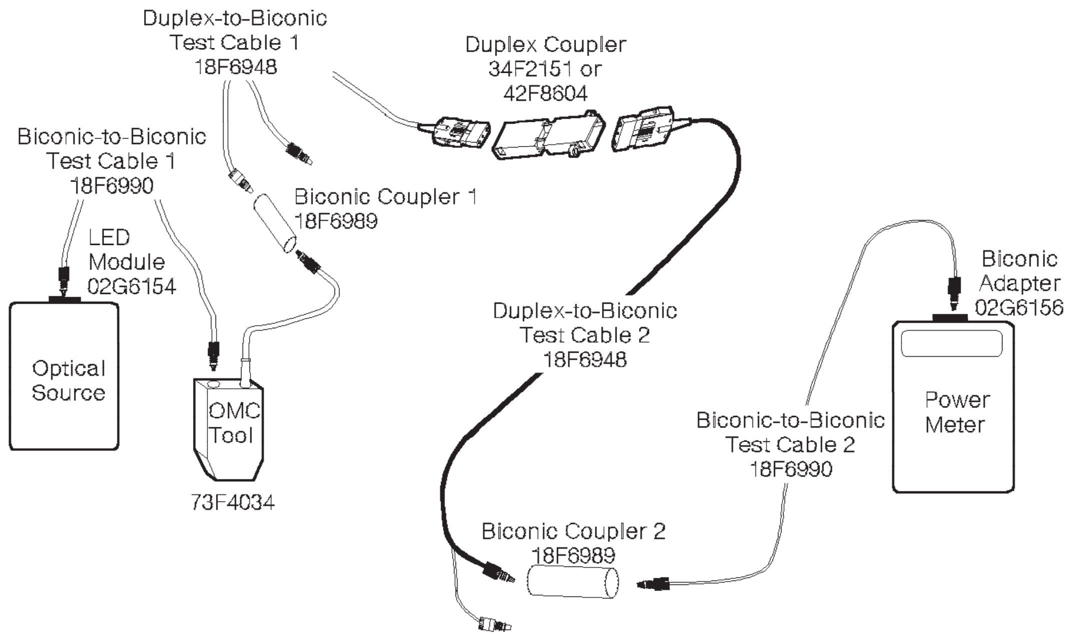


Figure 3-14. Obtaining **P2** *for a Multimode Link*

Obtaining P3 for a Multimode Link

Notes:

- Although this procedure refers only to duplex-to-biconic jumper cables, it also can be performed using IBM duplex-to-ST or duplex-to-FC cables and their associated adapters and couplers.
- If a step directs you to connect a test component that is already attached, continue with the next step.

This procedure applies only to ESCON or ATM long wavelengths links; other multimode laser links such as FICON SX or Gigabit Ethernet SX may use the same procedures as for singlemode fiber attachment.

P3 is used as a reference level for a duplex-to-biconic jumper cable when the direction of light propagation is from the optical source into the biconic connector and out of the duplex connector into the power meter.

1. Obtain P0 if you have not already done so, or if power to the optical source has been switched off.
2. Make sure all connectors are clean; then assemble the components (see Figure 3-15 on page 3-36).
   a. Attach one end of biconic-to-biconic test cable 1 to the optical source; then attach the other end to the OMC tool.
   b. Attach the cable from the OMC tool to one end of biconic coupler 1.
   c. Attach one end of biconic-to-biconic test cable 2 to biconic coupler 1; then attach the other end to biconic coupler 2.
   d. Attach the white-coded biconic connector of duplex-to-biconic test cable 1 to the other end of biconic coupler 2; then attach the duplex connector to the duplex coupler.
   e. Attach the duplex connector of duplex-to-biconic test cable 2 to the duplex coupler; then attach the black-coded biconic connector to the power meter.
3. Observe the power meter display. The maximum difference allowed between P3 and P0 is 2.5 dB.
   - If the difference is **less** than 2.5 dB, record the value P3 on the work sheet selected from Appendix E, “Work Sheets,” on page E-1 in the area labeled Py for the fiber being tested; then go to the next step.
   - If the difference is **greater** than 2.5 dB, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace each cable and then each coupler with known operational components until the test does not fail. If the test continues to fail, replace the OMC tool, then the optical source, and finally the power meter.
4. Remove duplex-to-biconic test cable 1 (between biconic coupler 2 and the duplex coupler) from the test equipment setup. **Do not** switch off power to the optical source, and **do not** disconnect the test cables or couplers from the optical source or the power meter.
5. Return to the MAP that directed you here.

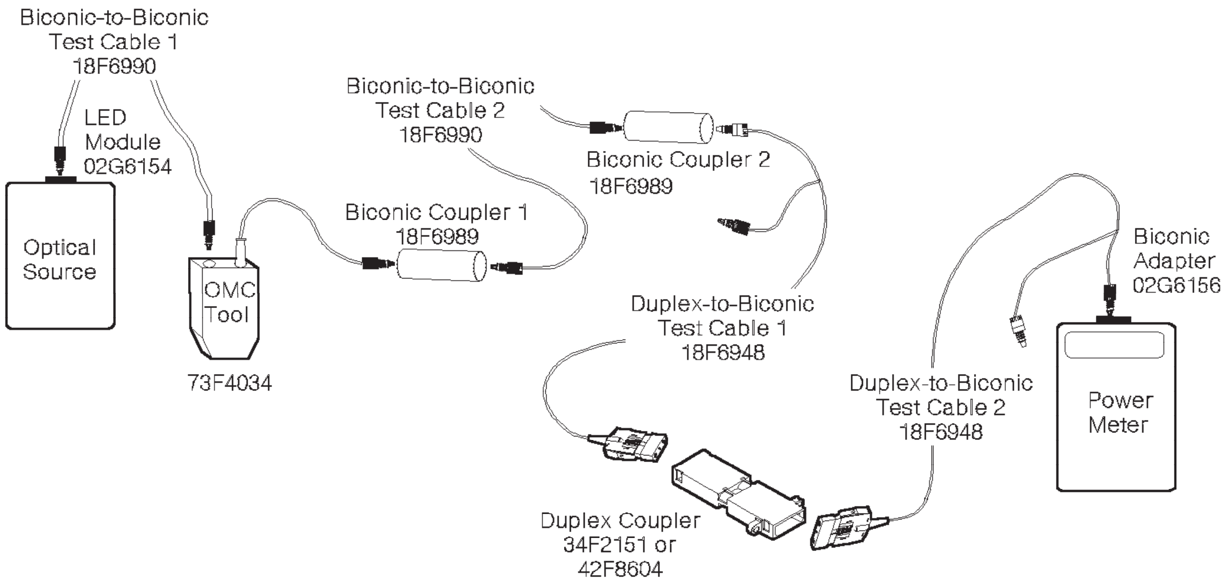


Figure 3-15. Obtaining **P3** *for a Multimode Link*

Obtaining **P0** for a Single-Mode Link

This procedure may also be used for short wavelength (SX) links if an 850 µm light source is available. This procedure ensures proper operation of the optical source and the power meter, and establishes the power output of the optical source. If you require detailed operating instructions for the test equipment, see the manufacturer's operating manuals. The IBM Fiber Optic Field Test Support Kits (see Appendix B, "Tools, Test Equipment, and Parts," on page B-1) provide space for these manuals.

1. Make sure 1) the connectors are clean, 2) the laser module "plug-in" and key are inserted into the optical source, and 3) the ST adapter is inserted into the power meter.
2. Switch on both instruments, and allow approximately 5 minutes for warm-up.

   Note: Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.
3. Set the power meter to 1300 nm.
4. Zero the power meter with darkened sensor.
5. Attach the yellow-coded connector of an ST-to-ST test cable to the optical source; then attach the red-coded connector to the power meter (see Figure 3-16).
6. Set the optical source to the maximum output position. The reading on the power meter display should be between -2.7 and -10.0 dBm.
   - If the reading **is** within specifications, record this value as **P0** on the work sheet selected from Appendix E, "Work Sheets," on page E-1 for the fiber being tested; then go to "Obtaining **P1** and Attaching Test Equipment to a Multimode Link" on page 3-30. Do not switch off power to the optical source.
   - If the reading **is not** within specifications, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace the cable, then the optical source, and finally the power meter with known operational components.

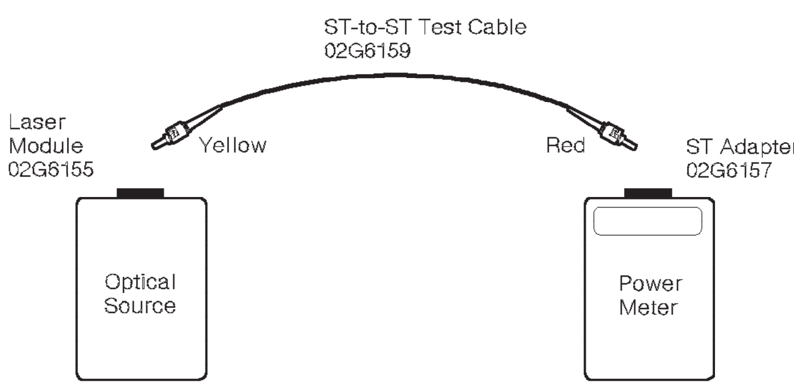


Figure 3-16. Obtaining **P0** *for a Single-Mode Link*

Obtaining P1 and Attaching Test Equipment to a Single-Mode Link

This procedure checks the single-mode test cables and establishes the power output of the optical source using these cables. It then shows how to attach this test equipment to a single-mode link terminated by duplex connectors on both ends.

1. Obtain **P0** if you have not already done so, or if power to the optical source has been switched off.
2. Make sure the laser module “plug-in” is inserted into the optical source, and the ST adapter is inserted into the power meter.
3. Make sure all connectors are clean; then assemble the test equipment (see Figure 3-17 on page 3-39).
   a. Remove the red-coded connector of ST-to-ST test cable 1 from the power meter; then attach it to an ST coupler.
   b. Attach the red-coded connector of ST test cable 2 to the other end of the ST coupler.
   c. Attach the yellow-coded end of ST test cable 2 to the power meter.
4. Observe the power meter display. The maximum difference allowed between **P1** and **P0** is 0.4 dB.
   - If the difference is **less** than 0.4 dB, record the value as **P1** on the work sheet selected from Appendix E, “Work Sheets,” on page E-1 for the fiber being tested; then go to the next step.
   - If the difference is **greater** than 0.4 dB, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace each cable and then each coupler with known operational components until the test does not fail. If the test continues to fail, replace the optical source and then the power meter.
5. Remove the ST coupler between the 2 ST-to-ST test cables. **Do not** switch off power to the optical source, and **do not** disconnect the test cables from the optical source or the power meter.
6. Attach the test equipment to the link as follows (see Figure 3-18 on page 3-39):
   a. Attach a duplex-to-ST adapter to each red-coded connector of the two ST-to-ST test cables.
      1) Attach ST-to-ST test cable 1 to the **A** side of duplex-to-ST adapter 1.
      2) Attach ST-to-ST test cable 2 to the **B** side of duplex-to-ST adapter 2.
   b. Connect one end of the link to duplex-to-ST adapter 1.
   c. Take the power meter and attached test equipment to the next point in the link you want to check; then connect that end to duplex-to-ST adapter 2.
7. Return to the MAP that directed you here.

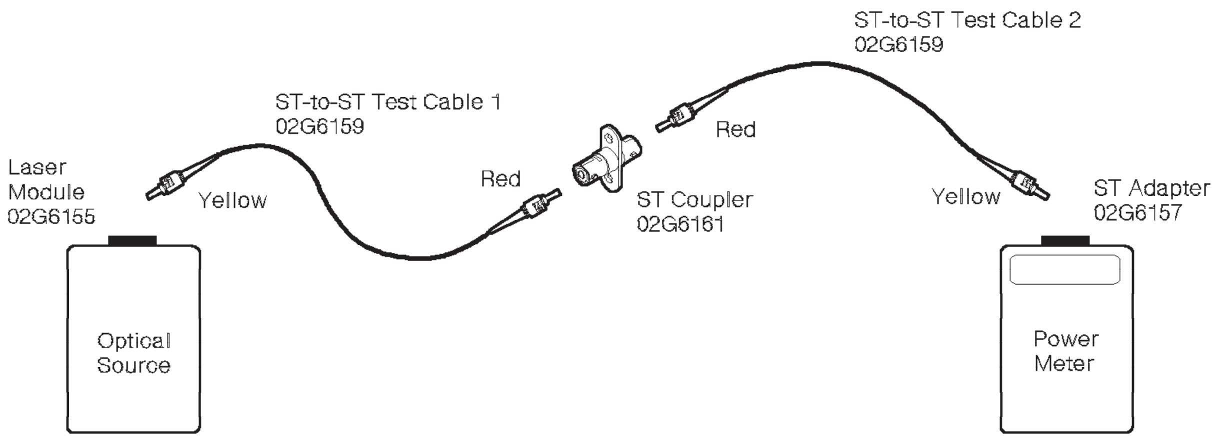


Figure 3-17. Obtaining **P1** *for a Single-Mode Link*

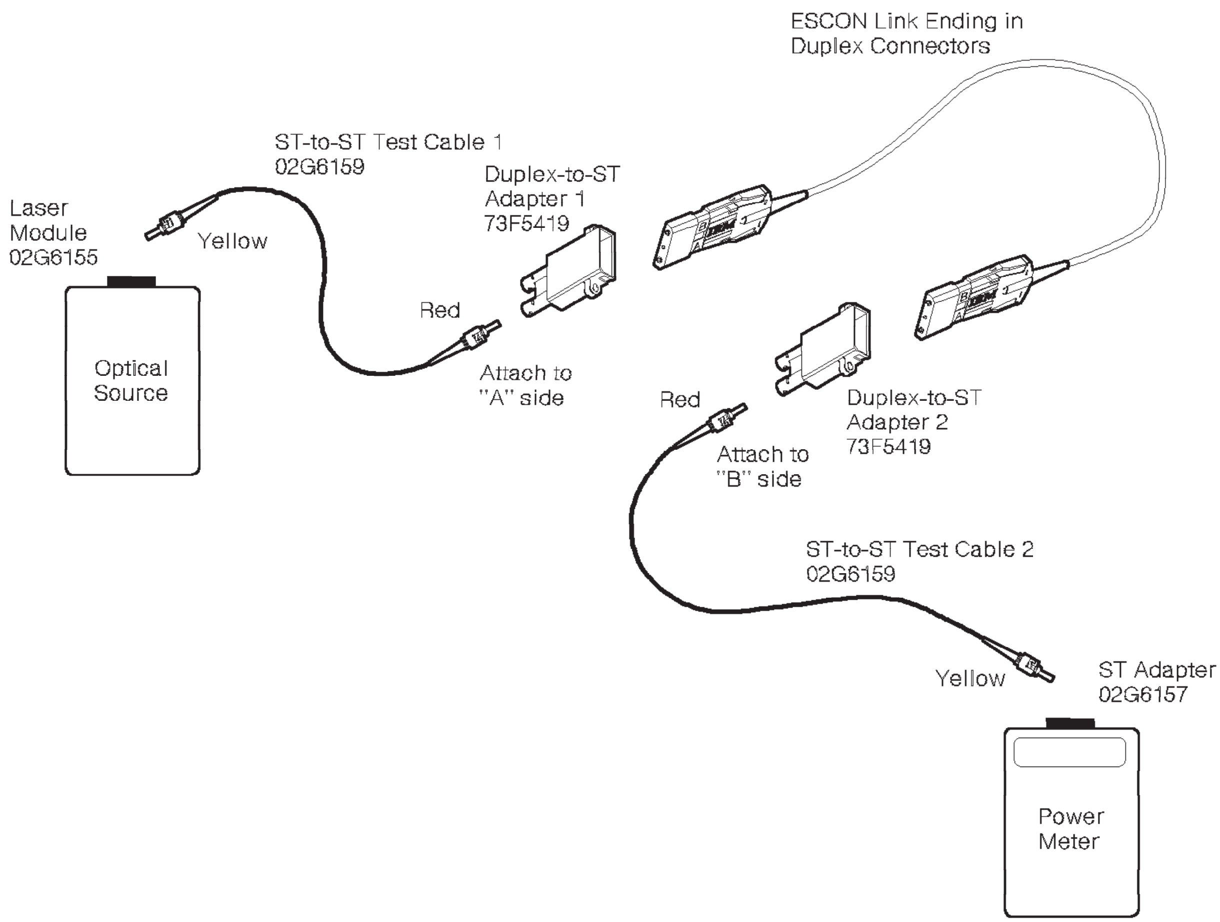


Figure 3-18. Connecting the Test Equipment to a Single-Mode Link

Chapter 4. Jumper Cable Handling and Installation Summary

This chapter provides guidance for handling fiber optic jumper cables and provides a summary of the tasks necessary to install them.

Jumper Cable Handling Precautions

The following precautions should be taken when handling fiber optic jumper cables:

- Make sure the cable cutouts in the floor tiles have the appropriate protective edging.
- Route the cables away from any sharp edges or projections that could cut the outer jacket.
- Do not route the cables near unprotected steam or refrigeration lines.
- Do not coil the cable to less than a 96.0-mm (3.78 in.) diameter.
- Do not bend the cable to less than a 12-mm (0.5 in.) radius.
- Do not pull cables into position; place them.
- Do not grasp the cable with pliers.
- Do not attach a pull rope or wire to the connectors.
- Always clean the connectors before attaching them.
- Do not remove the protective plugs or protective covers until you are ready to clean the connectors and attach the cables to a device.
- Always leave the protective plugs and protective covers on unused ports and cable connectors.
- Connect the cable carefully to prevent damage to the connector housing or the fiber optic ferrules.
- Before inserting the connector, make sure the connector and receptacle keying are aligned.
- Ensure that each FDDI connector has the correct keys installed for the intended application.

Pre-installation Checklist

Cable Inventory

- **Quantity:** Ensure that you have enough jumper cables.
- **Length:** Ensure that the jumper cables are long enough to reach each device or distribution panel, and that they have an additional length to allow for correct bend radius, slack, and minor equipment relocation.
- **Connectors:** Ensure that each end of the jumper cable has a compatible connector for attachment to the intended device or distribution panel, and that the connectors have protective covers.

Jumper Cable Installation Summary

This section summarizes the installation process; it **does not** provide detailed installation instructions. IBM Global Services offers the Fiber Transport Services (FTS), which is a structured cabling system compatible with ESCON and SC duplex optical connectors. For details, contact your local Global Services representative.

Jumper Cable Labeling

Each IBM jumper cable has a jacket marking that contains the part number, EC number, length in meters and feet, and manufacturing/warranty data. Additional jacket markings may be added by the suppliers.

Example:

```
PN VVVVVVV/FFFFFFF EC1234567 31 m 100.0 ft 11210005 BAR CODE DATE ODE SNUM
```

Where V = variable length part number, F = fixed length part number. Manufacturing and warranty data includes: BAR CODE INFO

1 Vendor code

1 Last digit of year manufactured

210 Day-of-year manufactured (Julian date)

005 Sequence number

The above is bar code information for reference.

Cable labeling tags (IBM part number 84X7035) are available through your IBM branch office. These tags should also be “to” locations.

Note: The ST and FC connectors on the end of an IBM jumper cable are color-coded and should be labeled as follows:
Black = Transmit (light into the link)
White = Receive (light from the link)

Note: Fiber optic jumper cables and connectors using the FICON SC-duplex connector may be obtained from vendors other than IBM, and may not have the bar code label or conform to the color coded labeling. Consult the manufacturer’s specifications for labeling conventions.

Safety Equipment

The following items should be available to warn of obstructions and hazardous conditions:
- Warning signs and tags
- Barricades for open floor tiles

Test Equipment

See *Technical Service Letter TSL #147 Fiber Optic Tools and test Equipment* (revised 2/19/96 or later) for a list of fiber optic tools and materials.

Documentation

The following documents should be available to ensure correct device connection:
- Floor plans
- Cable routing diagrams (as required)
- Physical configuration
- Logical configuration

Cable Routing

- **Raised floor:** Fiber cables can be installed under a raised floor. The following precautions must be taken besides those for IBM bus and tag cables:
  - Do not place the cables on top of moisture sensors or smoke detectors.
  - Cables should not be secured if an unloaded bend radius of less than 12 mm (0.5 in.) can exist.

    Note: This precaution applies to cables installed both above and below a raised floor.
- **Raceway or cable tray:** Cables should be placed, not pulled, in a tray or raceway.
- **Ceiling or partition:** Cables must be protected from sharp corners, ceiling hangers, pipes, dropped ceiling grids, metal partition studs, and construction activity. Conduit can be used when additional protection is required.
- **Vertical shaft (between floors):** Cable should be left on the shipping spool, or in a loose coil, and lowered from above.

  For installation in a vertical shaft, the cable must be protected against extreme temperature and possible damage from moving equipment. Cable ties must be used to secure the cable at intervals of 3 meters (10 ft.), and strain relief must be provided at intervals of 100 meters (328 ft.).
- **Plenum:** IBM jumper cables for FICON, FDDI, ATM, and GEN are plenum rated. ESCON cables for plenum installation are available by special request from IBM.

Cable Layout, Slack Management, and Strain Relief

There should be at least 2 meters (6.5 ft.) of cable at each end for any future equipment relocation.

Slack management should be used when storing excess jumper cable.

Strain relief, provided by devices and distribution panels, should be used to prevent connector damage.

Connector Protection

Attach connectors carefully to prevent damage to the housing or the fiber optic ferrules.

If possible, leave connectors in their protective shells until you are ready to attach them to the receptacles. Also, use the shells when temporarily unplugging the connectors.

Unused fiber optic duplex receptacles on an IBM device must have a protective plug (IBM part number 18F4017, 17G5609, or 78G9610) installed to prevent contamination (seeFigure 4-1 on page 4-4 or Figure 4-2 on page 4-4).

For non-IBM connectors, use the protection method recommended by the vendor for that connector.

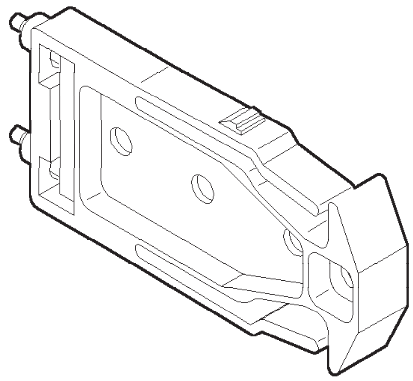


Figure 4-1. ESCON Protective Plug (Part Number 18F4017)

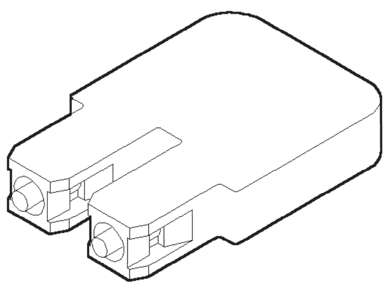


Figure 4-2. Optical Wrap/Protective Plug for FICON Links. IBM part numbers 16G5609 for multimode and 78G9610 or 86F1180 for single-mode. IBM part number 81G3185 (not shown) can also be used for multimode.

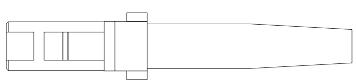


Figure 4-3. MT-RJ Wrap Plug

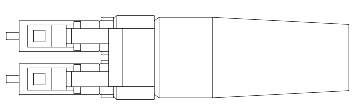


Figure 4-4. LC Wrap Plug

Chapter 5. Documentation

This chapter summarizes the information used to document link installations and provides instructions and a sample work sheet for recording link specifications and physical characteristics.

Cable Administration Information

As the customer's fiber optic channel link environment grows, accurate records must be maintained to list the changes, modifications, and reconfigurations within the environment. This chapter describes the documentation required, explains the various types of ESCON link connections, and shows an example of the entries used to complete a *Cable Administration Work Sheet*, SX23-0415.

Link Installation Documentation

The following documentation and information should be available to ensure link compatibility exists for IBM devices:
- Floor plans of existing facilities
- Switching and multiplexing requirements
- Equipment locations
- Logical connectivity diagrams
- Cable routing diagrams
- Installer's records

Documentation for New Installations

The following documentation and information should be available for new installations to ensure link compatibility exists for IBM devices:
- Link loss measurements.
- Contractor's warranty or verification statement.
- Compliance with national, state, and local building codes. New requirements have been added that specifically relate to installation of fiber optic cabling.

Documentation for All Installations

The following documentation and information should be available for all installations to ensure link compatibility exists for IBM devices:

- Device and link distances
- Product specifications
- Cable routing diagrams:
  - Location and length of each link
  - Type, location, and identification of connectors, adapters, and couplers
  - Locations of splices and distribution panels
- Manufacturer's data sheets:
  - Cable (see Appendix A, "Specifications," on page A-1 for specification requirements)
  - Bend radius control
  - Connectors
  - Strain relief
  - Splices
  - Distribution panels
  - Attached devices
  - Installer's warranty or verification statements

Link Connections and IOCDS and Cable Information

A link environment can consist of all fiber optic cables, or it can consist of copper bus and tag cables and fiber optic jumper and trunk cables. The following figures show these three link types:

- Logical link connection (Figure 5-1)
- Physical point-to-point link connection (Figure 5-2 on page 5-3)
- Complex physical link connection (Figure 5-3 on page 5-3)

The complex physical link connection is used to complete the *Cable Administration Work Sheet* example shown on page Figure 5-4 on page 5-6.

Logical Link Connection

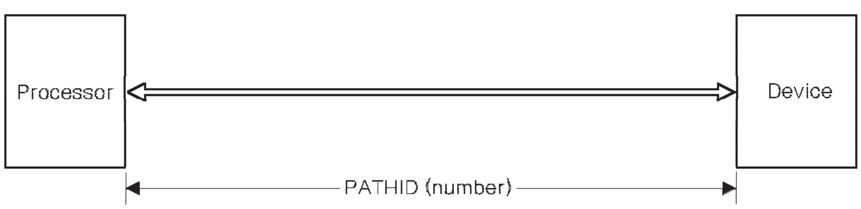


Figure 5-1. Example of a Logical Link Connection

IOCDS and Cable Information:

PATHID	M/T	Serial	CHPID	Length	M/T	Serial	Conn ID
309001	3090	xxxx	01	100 ft.	3803	yyyy	02

Physical Point-to-Point Link Connection

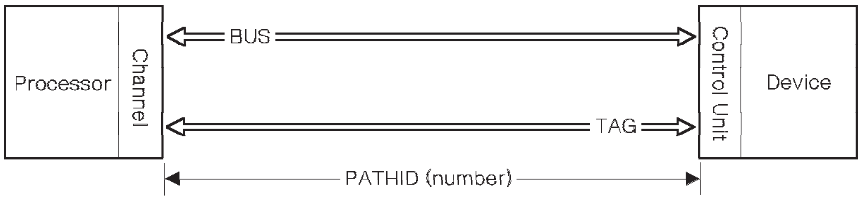


Figure 5-2. Example of a Physical Point-to-Point Link Connection

IOCDS and Cable Information:

PATHID	**M/T**	**Serial**	**CHPID**	**Length**	**M/T**	**Serial**	**Conn ID**
309001	3090™	xxxx	01	100 ft.	3803	yyyy	02

Complex Physical Link Connection

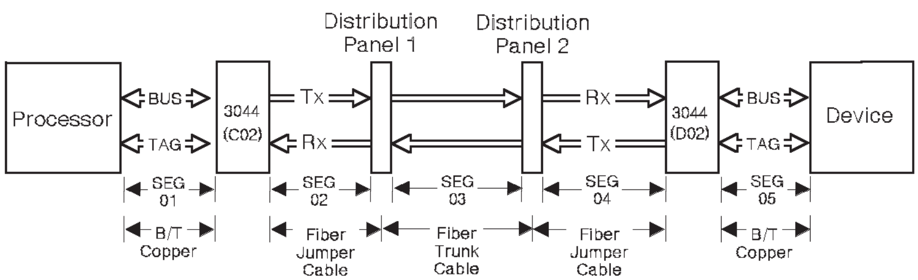


Figure 5-3. Example of a Complex Physical Link Connection

Completing the Cable Administration Work Sheet

The following paragraphs list and explain the entries used in the completed *Cable Administration Work Sheet* example shown in Figure 5-4 on page 5-6. The work sheet uses the complex physical link connection shown in Figure 5-3 as a basis and includes typical information available for that link.

When comparing Figure 5-3 to the completed work sheet, notice where the information for one link segment ends and the other begins. For example, the column under *3090-12345* ends at the ***To Label*** entry of *3044-12345,* which is the end of link segment *01*. Link segment *02* then begins at the top of the next column (*3044-98765*) and ends at Distribution Panel 1 (labeled *DP01C01 DP01C02*). Continue down this column and up from the bottom of the next column to determine the trunk information (link segment *03*). In the same manner, continue up the same column and down the next column for link segment *04* and *05* information.

Product Information

The ***Product Information*** column (**1**) consists of:

- **Machine Type:** The numeric (or alphanumeric) machine type.

  Note: Always start with the device closest to the processor or at the processor.
- **Ser#:** The 5-digit serial number.
- **Port#:** The port or channel path identifier (CHPID) of the device.
- **Strain Relief Used? (Y/N):** Is the device strain relief used?

Jumper Cable Information

The ***Jumper Cable Information*** column (**2**) consists of:

- **Vendor:** The provider of the jumper cable assembly.
- **Length (meter or ft):** The length of the jumper cable in meters or feet. Either unit of measure is acceptable. It is specified in the cable label information. If not known, estimate the actual length.
- **Loss (dB or dB/km) and Bandwidth (MHz•km) Specifications:** Complete this column for non-IBM multimode jumper cables only.
- **Modified? If yes, Loss Measurement Fiber 1/Fiber 2:**

  Note: Cable modification is **not recommended**. For example, modification voids the cable warranty, and modified components are not supported by the IBM fiber optic tool kits.

  If the jumper cable was modified, record the loss measurement for fiber 1 and fiber 2.
- **Connector Types:** The device end is a duplex connector unless the cable is attached to an original equipment manufacturer (OEM) device that uses other than a duplex receptacle. The other end depends on the type of distribution panel adapter or coupler used.
- **Slack Storage? (Y/N):** Is cable slack managed by using a slack-storage device?
- **From Label Fiber 1/Fiber 2 M/T Serial:** Unique label information at the “from” end of the cable (the distribution panel or device).
- **Path ID/Segment ID:** Path and segment identification.
- **To Label Fiber 1/Fiber 2:** Unique label information at the “to” end of the cable (the distribution panel or next device).

Trunk Information

The ***Trunk Information*** column (**3**) consists of:

- **Cable Manufacturer and Fiber Core Size (µm):** The cable manufacturer and the fiber core size in µm.
- **Installer:** Name of the company or contractor.
- **Length (km or ft):** Length of the trunk cable in kilometers or feet. Either unit of measure is acceptable.
- **Attenuation Specification (dB/km) or Loss Measurement (dB):** Trunk loss in dB/km (from the cable manufacturer) or dB (from the installer).
- **Bandwidth Specification (MHz•km):** Multimode only. Specified by the cable manufacturer (for example, 500 MHz•km).
- **# of Splices and Type:** Should be part of the link schematic. Note if the splice is mechanical or fusion.
- **Connector Type(s) at Panel(s):** Type of connector used at the distribution panel (for example, IBM duplex, ST).
- **OTDR Print? If yes, ID:** Contractors and installers could have used an optical time domain reflectometer (OTDR) to record link trace information. Either hardcopy or softcopy records are acceptable and should provide link identification information.
- **From Panel ID Fiber 1/Fiber 2:** Distribution panel "from" locations for fiber 1 and fiber 2.
- **Path ID and Segment ID:** Path and segment identification.
- **To Panel ID Fiber 1/Fiber 2:** Distribution panel "to" locations for fiber 1 and fiber 2.

Loss Measurements

The ***Loss Measurements*** column (**4**) consists of:

- **Date Tested:** Date when link verification was performed.
- **End-End Link Verification Loss (dB):** Link loss from device connector to device connector.

Service Comments

The ***Service Comments*** column (**5**) can be used for information such as:
- IBM contract number
- Service comments
- OEM device information (machine type and serial)
- Hazardous area identification

Cable Administration Work Sheet

							Machine Type Ser # Port #	Product Information 1
							Strain Relief Used? (Y/N)	
							Vendor	Jumper Cable Information 2
							Length (meter or ft)	
							Loss (dB or dB/km) and Bandwidth (Mhz •km) Specifications	
							Modified? If yes, Loss Measurement Fiber 1/Fiber 2	
							Connector Types	
							Stack Storage? (Y/N)	
							From Label Fiber 1/Fiber 2 M/T Serial	
							Path ID/Segment ID	
							To Label Fiber 1/Fiber 2	
							Cable Manufacturer and Fiber Core Size (μm)	Trunk Information 3
							Installer	
							Length (km or ft)	
							Attenuation Specification (dB/km) or Loss Measurement (dB)	
							Bandwidth Specifications (Mhz• km)	
							# of Splices and Type	
							Connector Type(s) and Panel(s)	
							OTDR Print? If Yes, ID	
							From Panel ID Fiber 1/Fiber 2	
							Path ID and Segment ID	
							To Panel ID Fiber 1/Fiber 2	
							Date Tested	Loss Measure-ment 4
							End-End Link Verification Loss (dB)	
								Service Comments 5

Figure 5-4. Example of a Cable Administration Work Sheet

Appendix A. Specifications

This chapter lists the specifications and optical properties for a fiber optic channel link, IBM jumper cables, and trunk cable. To allow for growth, a trunk cable with higher modal bandwidth than the minimum specification should be considered. In FDDI applications, 100/140 μm fiber is not prohibited but it is not recommended for new installations.

Link Specifications

Table A-1 on page A-3 lists the specifications for links using singlemode (9/125-µm), or multimode (62.5/125-µm, or 50/125-µm) fiber cable. The trunk to which the IBM jumper cables are connected must have optical properties that conform to the specifications in the table.

Table A-1. Link Specifications

Link/Fiber Type	Maximum Length	Maximum Loss	Trunk Size/ Wavelength	Minimum Trunk Modal Bandwidth	Notes
ESCON					
Multimode	2.0 km (1.24 mi.)	8.0 dB	62.5 µm/LX	500 MHz•km	1, 3, 8
Multimode	2.0 km (1.24 mi.)	8.0 dB	50.0 µm/LX	800 MHz•km	1, 3, 4, 8
Multimode	3.0 km (1.86 mi.)	8.0 dB	62.5 µm/LX	800 MHz•km	1, 3, 4, 8
Single-Mode	20 km (12.4 mi.)	14.0 dB	9 to 10µm/LX	NA	1, 2, 3, 5, 6, 7, 10
Sysplex Timer® (ETR/CLO) Same as Multimode ESCON					
Coupling Facility Links					
Multimode (discontinued May, 1998)	1.0 km (.62 mi.)	8.0 dB	50.0 µm/SX	500 MHz•km	1, 3, 9
Single-Mode 1.06 and 2.1 Gbit/s	10 km (6.21 mi.)	7.0 dB	9 to 10µm/LX	NA	1, 3, 5, 6, 7
Single-Mode card with 50 micron optical mode conditioner over multimode fiber	550 meters (0.34 mi.)	5.0 dB	50.0 µm/LX		
FDDI					
Multimode	2.0 km (1.24 mi.)	9.0 dB	62.5 µm/LX	800 MHz•km	1, 3, 4
ATM					
Multimode	2.0 km (1.24 mi.)	11.0 dB	62.5 µm/LX	800 MHz•km	1, 3
Single-Mode	2.0 km (1.24 mi.)	15.0 dB	9 to 10 µm/LX	NA	1, 3, 5, 6, 7
FICON LX					
Multimode with 50 micron optical mode conditioner	550 meters (0.34 mi.)	5.0 dB	50.0 µm/LX	500 MHz•km	1, 3, 12, 13
Multimode with 62.5 micron optical mode conditioner	550 meters (0.34 mi.)	5.0 dB	62.5 µm/LX	160 MHz•km	1, 3, 12, 13
Single-Mode 1gb	10.0 km (6.2 mi.)	7.8 dB	9 to 10µm/LX	NA	1, 3, 5, 6, 7
Single-Mode 2gb	10.0 km (6.2 mi.)	7.8 dB	9 to 10µm/LX	NA	1, 3, 5, 6, 7
FICON SX					
Multimode 1gb	500 meters (0.34 mi.)	3.85 dB	50.0 µm/SX	500 MHz•km	1, 3, 9
Multimode 2gb	300 meters (0.19 mi.)	2.62 dB	50.0 µm/SX	500 MHz•km	1, 3, 9
Multimode 1gb	250 meters (0.16 mi.)	2.76 dB	62.5 µm/SX	160 MHz•km	1, 3, 9
Multimode 2gb	120 meters (0.07 mi.)	1.98 dB	62.5 µm/SX	160 MHz•km	1, 3, 9
Multimode 1gb	300 meters (0.19 mi.)	3.0 dB	62.5 µm/SX	200 MHz•km	1, 3, 9
Gigabit Ethernet (GbE) LX					
Multimode with 50 micron optical mode conditioner	550 meters (0.34 mi.)	2.4 dB	50.0 µm/LX	500 MHz•km	1, 3
Multimode with 62.5 micron optical mode conditioner	550 meters (0.34 mi.)	2.4 dB	62.5 µm/LX	500 MHz•km	1, 3
Single-Mode	5 km (3.1 mi.)	4.6 dB	9 to 10µm/LX		1, 3, 5, 6, 7
Gigabit Ethernet (GbE) SX					

Table A-1. Link Specifications (continued)

Link/Fiber Type	**Maximum Length**	**Maximum Loss**	**Trunk Size/ Wavelength**	**Minimum Trunk Modal Bandwidth**	**Notes**
Multimode 50 micron	550 meters (0.34 mi.)	3.6 dB	50.0 µm/SX	500 MHz•km	1, 3
Multimode 62.5 micron	275 meters (0.17 mi.)	2.6 dB	62.5 µm/SX	200 MHz•km	1, 3

Notes:

1. The maximum link length includes both jumper and trunk cables.
2. The ESCON Extended Distance feature (ESCON XDF) must be installed in both the channel and the ESCON Director to obtain a maximum link length of 20 kilometers (12.4 miles).
3. If the customer uses IBM's Fiber Transport Services (FTS), contact the marketing representative for distance considerations.
4. The maximum total jumper cable length cannot exceed 244 meters (800 ft.) when using either 50/125-µm trunk fiber or when a 62.5/125-µm link exceeds 2 kilometers (1.24 miles).
5. Single-mode connectors and splices must meet a minimum return loss specification of 28 dB.
6. In a single-mode jumper cable, the minimum distance between connectors or splices is 4 meters (13.1 ft.).
7. In a single-mode trunk cable, the distance between connectors or splices must be enough to ensure that only the lowest-order bound mode propagates.
8. The maximum link loss for multimode fiber includes the higher-order-mode loss, which is 1.5 dB for 50 µm and 1.0 dB for 62.5 µm on ESCON links only.
9. Short wavelength (SX) versions of Gigagit Ethernet and FICON multimode links use a short wavelength laser (780 to 850 nm) over multimode fiber. Fiber loss at these wavelengths (3 to 4 dB/km) is higher than for other links using 1300 nm lasers (0.5 dB/km).
10. Some single-mode ESCON transceivers use the FICON duplex connector rather than the IBM ESCON duplex connector. The maximum length and loss values are the same for both connector types and the maximum loss/distance is not reduced by using the ESCON adapter kit (part number 46H9223).
11. The maximum FDDI link loss includes a system loss of 2.0 dB, which includes higher order mode losses, extinction ratio, and retiming penalties.
12. Although the ANSI Fibre Channel Connection does not support the use of long wavelength (1300 nm) lasers on multimode fiber, IBM will support this combination. Special mode conditioning patch cables or couplers may be required; Refer to the *Fiber Channel Connection (FICON I/O Interface Physical Layer*, SA24-7172.
13. The use of MCP cables is not supported over 1 gb.

Typical Optical Component Loss Values

The following loss values are typical for optical components used in the data communication industry. Use the manufacturer's loss values if available.

Table A-2. Typical Optical Component Loss

Component	Description	Size (μm)	Mean Loss	Variance (dB^2)
Connector	Physical contact	62.5 to 62.5	0.40 dB	0.02
(See note 1)		50.0 to 50.0	0.40 dB	0.02
		9.0 to 9.0 **(See note 2)**	0.35 dB	0.06
		62.5 to 50.0	2.10 dB	0.12
		50.0 to 62.5	0.00 dB	0.01
		100 to 100	0.40 dB	0.02
		100 to 62.5	4.72 dB	0.12
Connector	Nonphysical contact	62.5 to 62.5	0.70 dB	0.04
(See note 1)	(Multimode only)	50.0 to 50.0	0.70 dB	0.04
		62.5 to 50.0	2.40 dB	0.12
		50.0 to 62.5	0.30 dB	0.01
		100 to 100	0.70 dB	0.04
		100 to 62.5	4.90 dB	0.12
Splice	Mechanical	62.5 to 62.5	0.15 dB	0.01
		50.0 to 50.0	0.15 dB	0.01
		9.0 to 9.0 **(See note 2)**	0.15 dB	0.01
		100 to 100	0.15 dB	0.01
Splice	Fusion	62.5 to 62.5	0.40 dB	0.01
		50.0 to 50.0	0.40 dB	0.01
		9.0 to 9.0 **(See note 2)**	0.40 dB	0.01
		100 to 100	0.40 dB	0.01
Cable	IBM Multimode jumper	62.5	1.75 dB/km	NA
	IBM Multimode jumper	50.0	3.00 dB/km at 850 nm	NA
	IBM Single-mode jumper	9.0	0.8 dB/km	NA
	Trunk	62.5	1.00 dB/km	NA
	Trunk	50.0	0.90 dB/km	NA
	Trunk	9.0	0.50 dB/km	NA

Notes:

1. The connector loss value is typical when attaching identical connectors. The loss can vary significantly if attaching different connector types.
2. Single-mode connectors and splices must meet a minimum return loss specification of 28 dB.

Appendix B. Tools, Test Equipment, and Parts

A complete list of fiber optic tools and test equipment is available in *Technical Service Letter TSL #147 Fiber Optic Tools and test Equipment*, revised 2/19/96 or later. This TSL contains a current list and description of all part numbers in the fiber optic tool kit, ordering information, and calibration of test equipment. Tool kits and field bills of material (BOMs) are available to service both single-mode and multimode optical fiber links using ESCON, Fiber Channel Connection (FICON or coupling facility links), FDDI, ATM, and GbE; attachment to ST, FC, and biconic connector types is also supported.

Appendix C. Measuring Device Transmit and Receive Levels

This section contains procedures on how to measure the dB power levels of the device transmit and receive signals. This section also contains information to isolate sections of a coupling facility channel link using the splitter tool.

An optical power meter is required for troubleshooting fiber optic problems. An optical power meter (12G8814) and adapter cables are available at branch offices as part of the IBM fiber optic field tool kits (46G6836, 46G6837, or 46G6839).

An alternate is the miniature optical power meter (MOP), IBM P/N 25F9767, that plugs into a digital voltmeter. RETAIN® tip H164015 contains information on part numbers, optical connection adapters, and ordering. Information is also available at the following IBM Intranet Web site at *http://9.51.80.190/tools/tool0506.nsf/*. After going to the Web site, search on 25F9767.

Set up the MOP meter and multimeter as follows:

1. Plug the MOP meter into the multimeter
   a. COM of the MOP meter to COM on the multimeter
   b. Other pin to DC Volts
2. Select the desired wavelength on the MOP meter
3. Select mVdc on the multimeter.

All of the procedures in this appendix describe methods of measuring optical power using the attached device as a source; this is the only way to measure SX links at 850 nm or wavelength multiplexed links around 1550 nm.

This chapter contains:

Measuring Receive-In Power

See Appendix C, “Measuring Device Transmit and Receive Levels,” on page C-1 for information about using the Miniature Optical Power meter, P/N 25F9767.

1. Switch on the power meter, and allow approximately 5 minutes for warm-up.

   Note: Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.

2. For long wavelength (LX = 1300nm) links, set the power meter to 1300nm.

   For short wavelength (SX = 850nm) links, set the power meter to 850nm.

   Note: Refer to Table A-1 on page A-3 for links which use LX or SX transmitters.

3. Zero the power meter with darkened sensor.
4. Make sure the connectors are clean; then assemble the test equipment using the appropriate figure:

   Figure C-1; ESCON multimode link

   Figure C-2 on page C-3; FDDI Multimode link

   Figure C-3 on page C-3; ATM, FICON, or singlemode FICON link

   Figure C-4 on page C-3; ESCON multimode link with MT–RJ connector

   Figure C-5 on page C-3; FICON or ISC-3 peer mode link with LC connector

   Note: Some FDDI devices can send test signals; ask the customer to have “halt” signals sent from these devices.

5. Observe the power meter display, and record the value on the work sheet. The receive level should read within the specifications for the channel type. See Table C-1 on page C-4.

   Note: If the level is within this range and the receiver is not operating properly, the device receiver optical port could be dirty, or the receiver could be defective.

6. Go to “Measuring Transmit-Out Power” on page C-5.

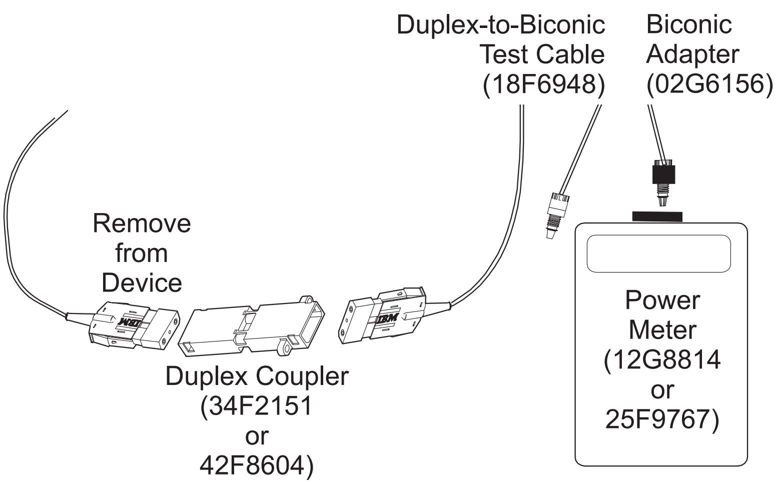


Figure C-1. Measuring Receive-In Power for an ESCON Multimode Link

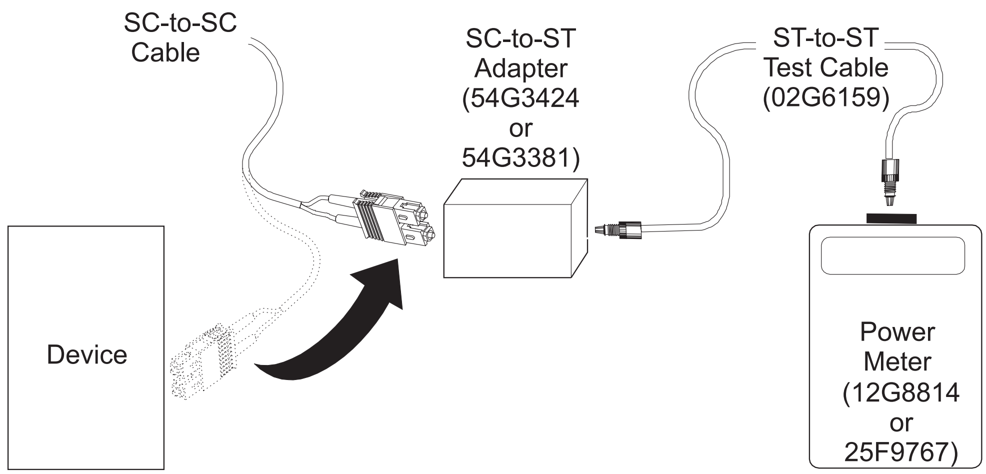


Figure C-2. Measuring Receive-In from the Multimode Link - FDDI

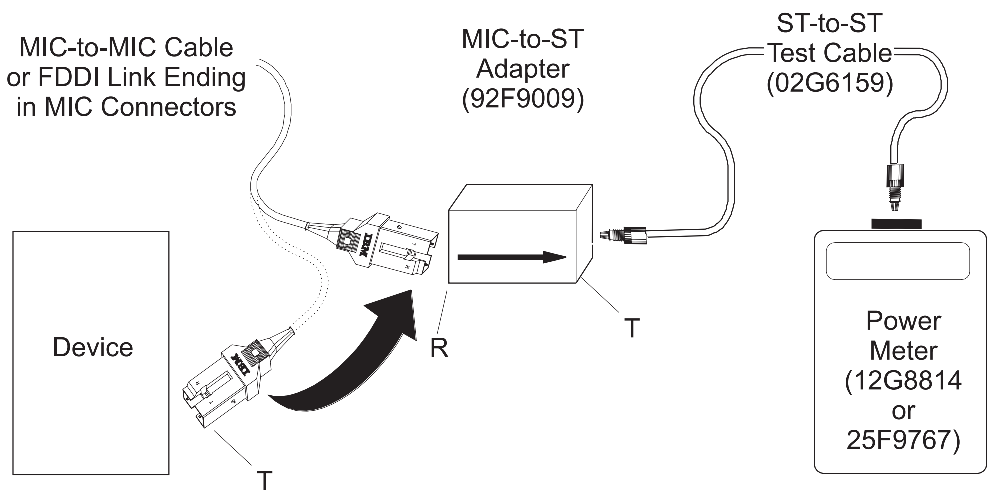


Figure C-3. Measuring Receive-In from the Link - ATM, FICON, or Singlemode FICON

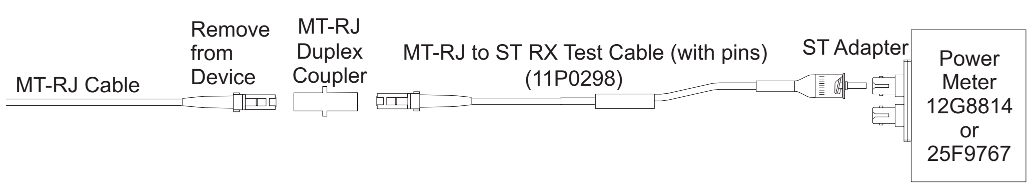


Figure C-4. Measuring Receive-In Power for A Multimode ESCON Link with MT–RJ Connector

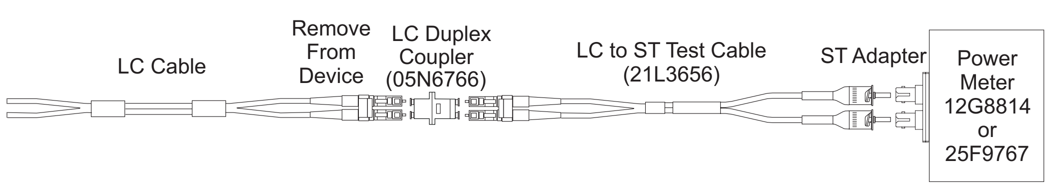


Figure C-5. Measuring Receive-In Power for A FICON or ISC-3 Peer Mode Link With LC Connector

Table C-1. Minimum and Maximum Acceptable Power Specifications

Link Type	TX Min	TX Max	RX Min	RX Max
FDDI	-19 dBm	-14 dBm	-32 dBm	-14 dBm
Multimode ATM	-19 dBm	-14 dBm	-30 dBm	-14 dBm
Single-mode ATM	-15 dBm	-8 dBm	-32.5 dBm	-8 dBm
Multimode FICON LX with MCP	-8.5 dBm	-4 dBm	-22 dBm	-3 dBm
Singlemode FICON LX	-8.5 dBm	-4 dBm	-22 dBm	-3 dBm
Multimode FICON SX	-9.5 dBm	-4 dBm	-17 dBm	-3 dBm
Multimode ESCON	-20.5 dBm	-15 dBm	-29 dBm	-14 dBm
Single-mode ESCON	-8 dBm	-3 dBm	-28 dBm	-3 dBm
Single-mode GbE	-11 dBm	-3 dBm	-19 dBm	-3 dBm
Multimode GbE	-9.5 dBm	-3 dBm	-17 dBm	-3 dBm
Coupling Facility Operating at 1 Gbit/s (compatibility mode)	-11 dBm	-3 dBm	-20 dBm	-3 dBm
Coupling Facility Operating at 2 Gbit/s (peer mode)	-9 dBm	-3 dBm	-20 dBm	-3 dBm
Sysplex Timer (ETR/CLO)	-20.5 dBm	-15 dBm	-29 dBm	-14 dBm

Measuring Transmit-Out Power

See Appendix C, “Measuring Device Transmit and Receive Levels,” on page C-1 for information about using the Miniature Optical Power meter, P/N 25F9767.

Note: The biconic or ST adapter should still be inserted into the power meter optical port, and the black-coded connector of the test cable should still be attached to the power meter.

1. Make sure the connectors are clean; then assemble the test equipment using the appropriate figure:

   Figure C-6; ESCON multimode link

   Figure C-7 on page C-6; FDDI Multimode link

   Figure C-8 on page C-6; ATM, FICON, or singlemode FICON link

   Figure C-9 on page C-6; ESCON multimode link with MT–RJ connector

   Figure C-10 on page C-6; FICON or ISC-3 peer mode link with LC connector
2. Observe the power meter display and record the value on the work sheet. The transmit level should read within specifications for the channel type. See Table C-1 on page C-4.

   Note: If the level is not within this range, the device transmitter optical port could be dirty, or the transmitter could be defective.
3. Remove the coupler from the link jumper cable, and reconnect the jumper cable to the device.
4. Have you obtained the transmit and receive levels for both devices?
   - If **Yes**, return to the fast-path step that directed you here.
   - If **No**, return to “Measuring Receive-In Power” on page C-2 and repeat the procedure for the other device.

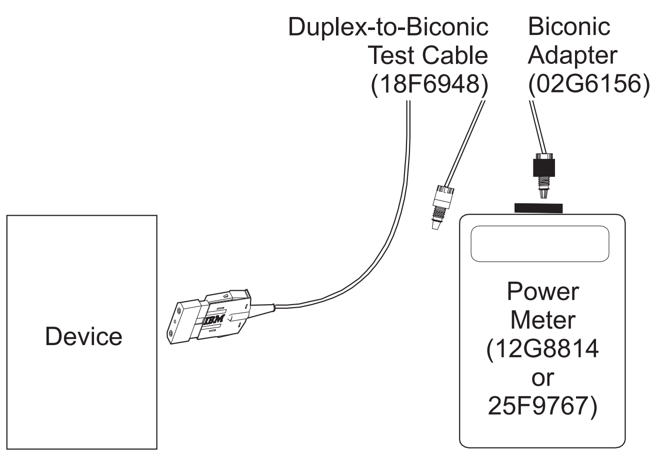


Figure C-6. Measuring Transmit-Out Power for an ESCON Multimode Link

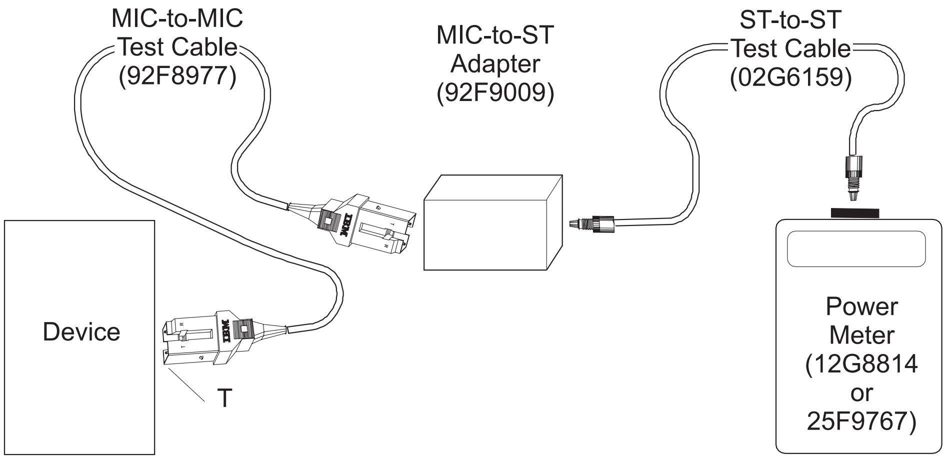


Figure C-7. Measuring Transmit-Out from a Multimode Device - FDDI

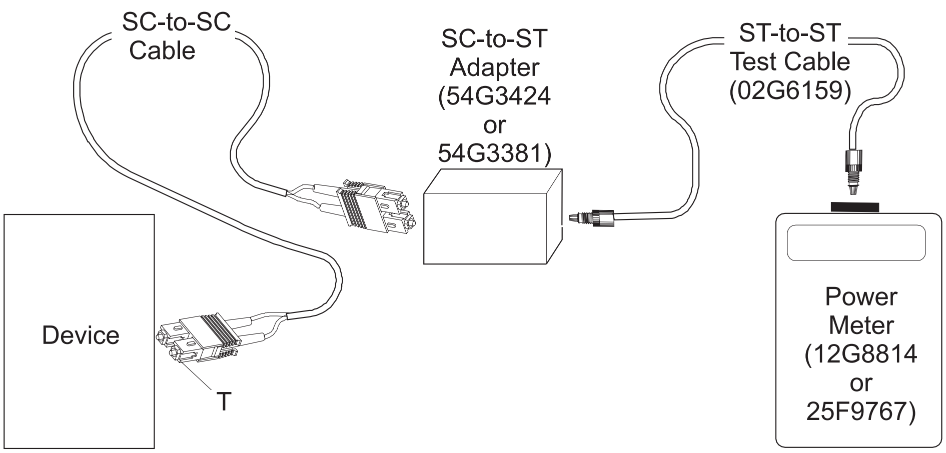


Figure C-8. Measuring Transmit-Out from a Device - ATM, FICON, or Singlemode ESCON

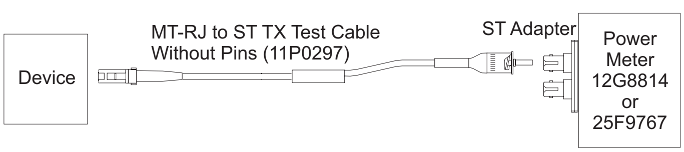


Figure C-9. Measuring Transmit-Out Power for A ESCON Link With MT– RJ Connectors

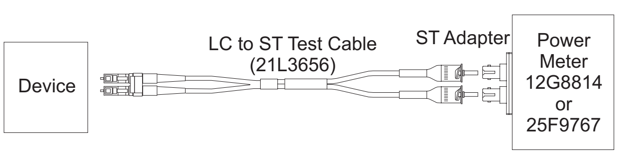


Figure C-10. Measuring Transmit-Out Power for A FICON or ISC-3 Peer Mode Link With LC Connectors

Coupling Facility Channel Link Multimode Power Level Measurement Procedures

Some coupling facility channel links use a different type of laser safety control than ESCON links, so they require a different method for measuring transmit and receive power levels. Coupling links operating at 2 Gbit/s (peer mode) do not require this procedure; the previous method for measuring singlemode links may still be used in this case (see Appendix C, “Measuring Device Transmit and Receive Levels,” on page C-1). Other coupling links operating at 1 Gbit/s use a safety method called Open Fiber Control (OFC); the transmitters on both ends of the link will only function if there is a complete fiber link between both pairs of transmitters and receivers. If the link is opened at any point (such as unplugging a connector or breaking a fiber) both transmitters automatically shut down as a safety measure. The transmitters will automatically turn on again within 10 seconds after the link is re-established. To maintain a complete link while measuring the power levels, it is necessary to use a fiber optic splitter to tap off a small amount of light from an operating link. This measurement can be used to determine the power levels in the link according to the following procedures.

Because some coupling links use OFC laser safety control, it is not possible to measure the fiber loss using the MAPs. All link problem determination and link verification for these links must be performed using the Fast Path method.

The coupling facility channel links use a different type of optical connector than the ESCON links. The SC duplex connector should be held by the sides of the connector body when plugging so that the fibers on the transmit and receive sides are not accidentally pushed together. The connector should plug with a maximum force of about 5 lbs.; if plugging is difficult, move the connector slightly side to side, rather than forcing it into the housing. The connector is keyed to allow insertion in only one orientation; note the orientation of the keys when you remove the connector so that it will be easier to re-insert.

Note: Standard SC duplex products are available from many vendors; When using a non-IBM cable, consult the customer’s specifications for insertion and withdrawal.

Measuring Device Transmitter and Receiver Levels

If you did not measure the transmitter and receiver levels of the device, as instructed by the device maintenance publication, use the following procedure.

See Appendix C, “Measuring Device Transmit and Receive Levels,” on page C-1 for information about using the Miniature Optical Power meter, P/N 25F9767.

This procedure must be performed before measuring the power levels on the channel.

1. Insert the optical wrap plug (part number 16G5609) into the optical channel and perform any available hardware diagnostic tests. This will determine if the optical transmitter and receiver card are functioning properly. This will not, however, determine if they are operating within specification limits.
2. Run the wrap tests using the wrap test procedure in the maintenance information manual for the device:

   If the wrap test fails, replace the channel card using the instructions in the maintenance information manual for the device. Then continue measuring the device transmitter and receiver levels using the procedure in that manual.

   If the wrap test completes successfully, insert the optical splitter tool (part number 54G3426). Attach the splitter connector marked “DEVICE TO BE MEASURED” into the optical transceiver and connect the rest of the test equipment (see Figure C-11 on page C-9).
3. Measure the transmit-out power level of the device; it should be between -8.7 and -16.5 dBm.

   Note: Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. This reading should be between -5.0 and +1.3 dBm.
4. If the transmit-out level is out of specification limits, replace the channel card. using the instructions in the maintenance information manual for the device. Then continue measuring the device transmitter and receiver levels using the procedure in that manual.
5. If the transmitter power is within specification limits, connect the test equipment (see Figure C-12 on page C-11).
6. Measure and record the receive-in power level.

   Note: **Do not** replace the card on the basis of this measurement, even if the power meter continues to read **L0**. A bad receiver light level may be caused by a fault in the fiber optic cable or in the transmitter on the other end of the link.
7. If this is your first time through this procedure, repeat steps 1 through 6 for the device attached to the other end of the link.

   If this is your second time through this procedure, continue with “Measuring Receive-In Power for a Multimode Coupling Facility Channel Link” on page C-10.

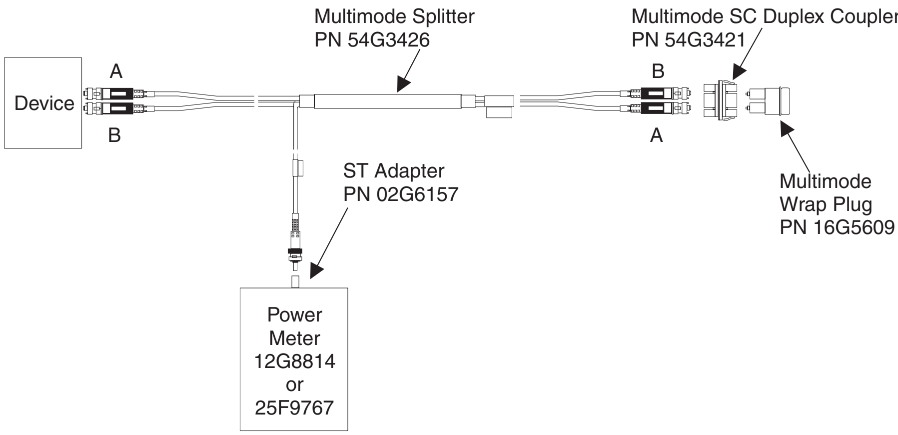


Figure C-11. Measuring Device Transmitter Levels for a Multimode Coupling Facility Channel Link

Measuring Receive-In Power for a Multimode Coupling Facility Channel Link

See Appendix C, “Measuring Device Transmit and Receive Levels,” on page C-1 for information about using the Miniature Optical Power meter, P/N 25F9767.

Make sure the connectors are clean; then assemble the test equipment (using Figure C-12 on page C-11) as follows:

1. Switch on the power meter, and allow approximately 5 minutes for warm-up.

   Note: Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.
2. Set the power meter to 850 nm.
3. Zero the power meter with darkened sensor.
4. Remove the SC duplex connector from the device whose receiver is to be measured. Attach the duplex connector of the splitter (part number 54G3426) labeled “DEVICE TO BE MEASURED” to the open end of the link, using the SC duplex coupler (part number 54G3421).
5. Attach the other, unmarked end of the splitter to the device. The splitter is now positioned to measure the optical power coming from the other end of the link into the device receiver.
6. Attach the ST connector adapter (part number 02G6157) to the power meter, and insert the ST connection from the splitter into the power meter.
7. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the link to re-establish transmitting, and for the power meter reading to stabilize before taking a reading. The power meter reading should be between - 8.7 dBm and - 26.5 dBm.

   Notes:

   a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. The receiver optical power should be between -15.0 dBm and + 1.3 dBm, ± 0.5 dBm.

   b. If the level **is not** within this range, the receiver is not getting enough light; either the transmitter is bad or there is a fault in the cable connecting the transmitter and receiver. Continue with “Measuring Transmit-Out Power for a Multimode Coupling Facility Channel Link” on page C-12.

      If the level **is** within this range and the receiver is not operating properly, the device receiver optical port could be dirty, or the receiver could be defective. Clean the TRS and repeat the measurement; if the level is still out of spec, then the receiver is defective; record the level measured, and replace the card with the defective receiver.
8. Go to “Measuring Transmit-Out Power for a Multimode Coupling Facility Channel Link” on page C-12.

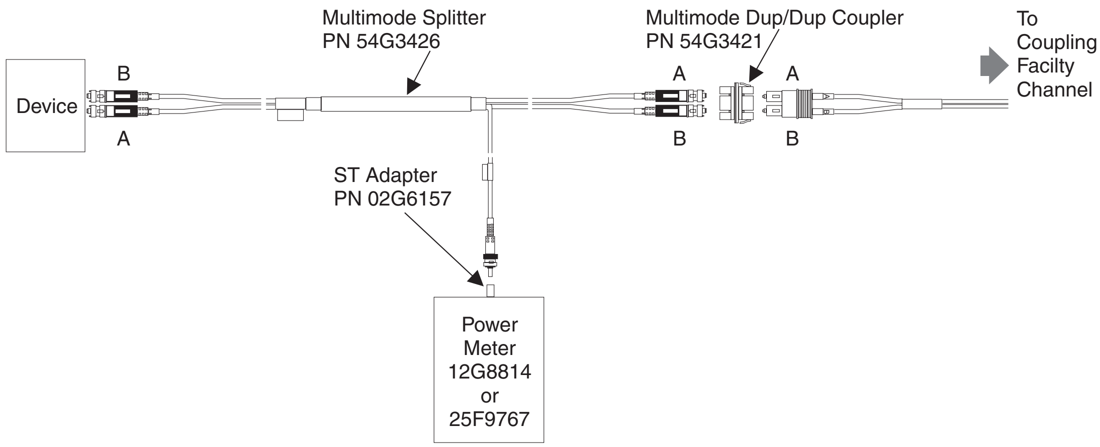


Figure C-12. Measuring Receive-In Power for a Multimode Coupling Facility Channel Link

Measuring Transmit-Out Power for a Multimode Coupling Facility Channel Link

Note: The ST connector of the splitter (part number 54G3426) should remain connected to the power meter.

See Appendix C, “Measuring Device Transmit and Receive Levels,” on page C-1 for information about using the Miniature Optical Power meter, P/N 25F9767.

Assemble the test equipment (using Figure C-13 on page C-13) as follows:

1. Remove the splitter from the device and the link.
2. Attach the splitter connector marked “DEVICE TO BE MEASURED” to the device, and attach the unmarked splitter connector to the link using the SC duplex coupler (part number 54G3421). The splitter is now positioned to measure the transmitter output power of the device.
3. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the link to re-establish transmitting, and for the power meter reading to stabilize before taking a reading. The power meter reading should be between - 8.7 dBm and - 16.5 dBm.

   Notes:

   a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. The transmitter optical power should be between -5.0 dBm and + 1.3 dBm, ± 0.5 dBm.
   b. If the level **is** within this range and the link is not operating properly, continue with the link maintenance procedure.

      If the level **is not** within this range, the device transmitter optical port could be dirty, or the transmitter could be defective. Clean the transmitter port and repeat the measurement; if the level is still out of range, the transmitter is defective; replace the card with the bad transmitter.
4. Remove the splitter from both the device and the link, and reconnect the link to the device.
5. Have you obtained the transmit and receive levels for both devices?
   - If **Yes**, return to the Fast Path step that directed you here.
   - If **No**, return to “Measuring Receive-In Power for a Multimode Coupling Facility Channel Link” on page C-10 and repeat the procedure for the other device.

     Note: The optical power meter reading taken with the splitter represents 10% of the true optical power in the link (10 dB), minus some loss associated with the splitter tool. The combined loss is marked on each splitter. To correct a power meter reading for the 10% power sampling, add the value given on the splitter to the power meter reading.

     This measurement procedure is accurate to within ±. 0.5 dB, because of variations in the splitter’s optical connectors.

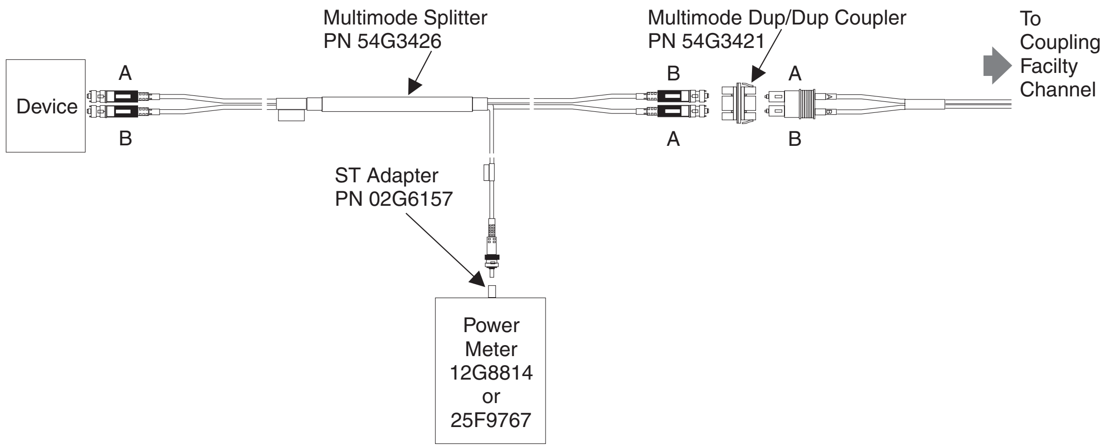


Figure C-13. Measuring Transmit-Out Power for a Multimode Coupling Facility Channel Link

Coupling Facility Channel Link Single-Mode Power Level Measurement Procedures

Some coupling facility channel links use a different type of laser safety control than ESCON links, so they require a different method for measuring transmit and receive power levels. Coupling links operating at 2 Gbit/s (peer mode) do not require this procedure; the previous method for measuring singlemode links may still be used in this case (see Appendix C, "Measuring Device Transmit and Receive Levels," on page C-1). Other coupling links operating at 1 Gbit/s use a safety method called Open Fiber Control (OFC); the transmitters on both ends of the link will only function if there is a complete fiber link between both pairs of transmitters and receivers. If the link is opened at any point (such as unplugging a connector or breaking a fiber) both transmitters automatically shut down as a safety measure. The transmitters will automatically turn on again within 10 seconds after the link is re-established. To maintain a complete link while measuring the power levels, it is necessary to use a fiber optic splitter to tap off a small amount of light from an operating link. This measurement can be used to determine the power levels in the link according to the following procedures.

Because some coupling links use OFC laser safety control, it is not possible to measure the fiber loss using the MAPs. All link problem determination and link verification for these links must be performed using the Fast Path method.

The coupling facility channel links use a different type of optical connector than the ESCON links. The SC duplex connector should be held by the sides of the connector body when plugging so that the fibers on the transmit and receive sides are not accidentally pushed together. The connector should plug with a maximum force of about 5 lbs.; if plugging is difficult, move the connector slightly side to side, rather than forcing it into the housing. The connector is keyed to allow insertion in only one orientation; note the orientation of the keys when you remove the connector so that it will be easier to re-insert.

Note: Standard SC duplex products are available from many vendors; if you are using a non-IBM cable, consult the vendor's specifications for insertion and withdrawal.

Measuring Device Transmitter and Receiver Levels

If you did not measure the transmitter and receiver levels of the device, as instructed by the device maintenance publication, use the following procedure.

This procedure must be performed before measuring the power levels on the channel.

1. Insert the optical wrap plug (part number 78G9610) into the optical channel and perform any available hardware diagnostic tests. This will determine if the optical transmitter and receiver card are functioning properly. This will not, however, determine if they are operating within specification limits.
2. Run the wrap tests using the wrap test procedure in the maintenance information manual for the device:
   - If the wrap test fails, replace the channel card using the instructions in the maintenance information manual for the device. Then continue measuring the device transmitter and receiver levels using the procedure in that manual.
   - If the wrap test completes successfully, insert the optical splitter tool (part number 54G3427). Attach the splitter connector marked "DEVICE TO BE

MEASURED” into the optical transceiver and connect the rest of the test equipment (see Figure C-14).

For ISC3, connect the LC to SC conversion kit, part number 05N4808, between the splitter and the device (see Figure C-15 on page C-16).

3. Measure the transmit-out power level of the device; it should be between -13.0 and -22.0 dBm.

   Note: Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. This reading should be between -11.0 and -3.0 dBm.
4. If the transmit-out level is out of specification limits, replace the channel card. using the instructions in the maintenance information manual for the device. Then continue measuring the device transmitter and receiver levels using the procedure in that manual.
5. If the transmitter power is within specification limits, connect the test equipment (see Figure C-17 on page C-18 or Figure C-15 on page C-16).
6. Measure and record the receive-in power level.

   Note: **Do not** replace the card based on of this measurement, even if the power meter continues to read **L0**. A bad receiver light level may be caused by a fault in the fiber optic cable or in the transmitter on the other end of the link.
7. If this is your first time through this procedure, repeat steps 1 through 6 for the device attached to the other end of the link.

   If this is your second time through this procedure, continue with “Measuring Receive-In Power for a Single-Mode Coupling Facility Channel Link” on page C-17.

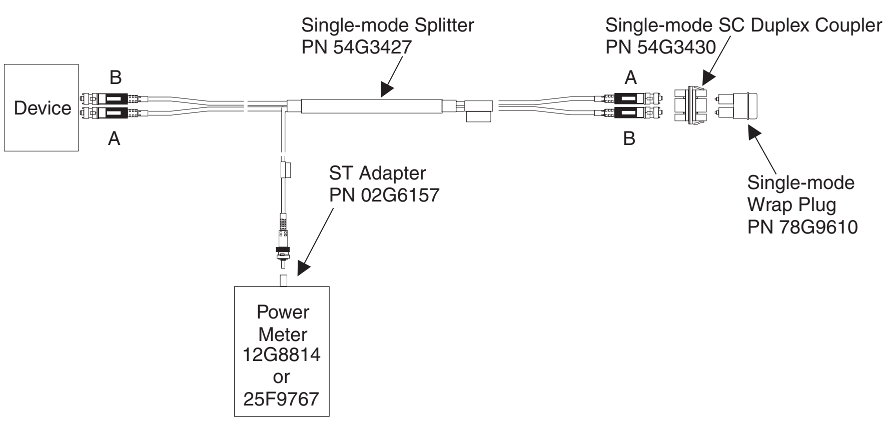


Figure C-14. Measuring Device Transmitter Levels for a Single-Mode Coupling Facility Channel Link

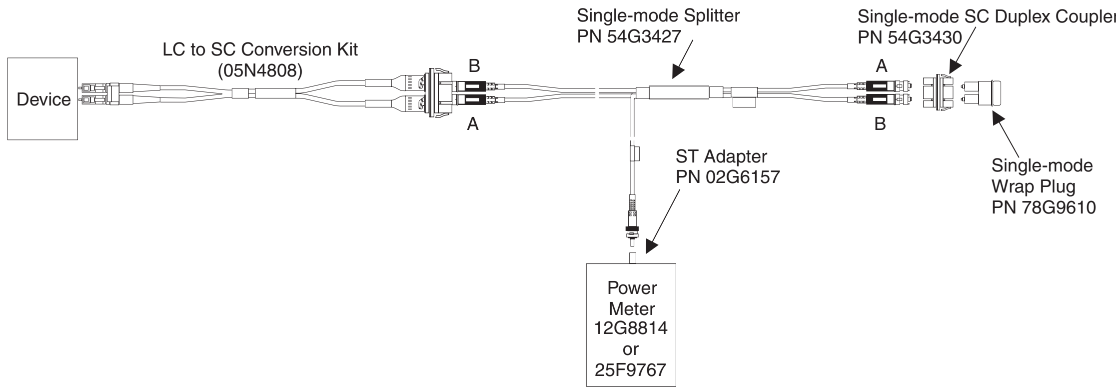


Figure C-15. Measuring Device Transmitter Levels for an ISC3 Operating at Compatibility Mode

Measuring Receive-In Power for a Single-Mode Coupling Facility Channel Link

Make sure the connectors are clean; then assemble the test equipment (using Figure C-16 or Figure C-17 on page C-18) as follows:

1. Switch on the power meter, and allow approximately 5 minutes for warm-up.

   Note: Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.
2. Set the power meter to 1300 nm.
3. Zero the power meter with darkened sensor.
4. Remove the SC duplex connector from the device whose receiver is to be measured. Attach the duplex connector of the splitter (part number 54G3427) labeled “DEVICE TO BE MEASURED” to the open end of the link, using the SC duplex coupler (part number 54G3430).

   For ISC3, connect the LC to SC conversion kit, part number 05N4808, between the splitter and the device (see Figure C-17 on page C-18).
5. Attach the other, unmarked end of the splitter to the device. The splitter is now positioned to measure the optical power coming from the other end of the link into the device receiver.
6. Attach the ST connector adapter (part number 02G6157) to the power meter, and insert the ST connection from the splitter into the power meter.
7. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the link to re-establish transmitting, and for the power meter reading to stabilize before taking a reading. The power meter reading should be between - 13.0 dBm and - 31.0 dBm.

   Notes:

   a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. The receiver optical power should be between -3 dBm and - 20 dBm, ± 0.5 dBm.

   b. If the level is within this range and the receiver is not operating properly, the device receiver optical port could be dirty, or the receiver could be defective.
8. Go to “Measuring Transmit-Out Power for a Single-Mode Coupling Facility Channel Link” on page C-19.

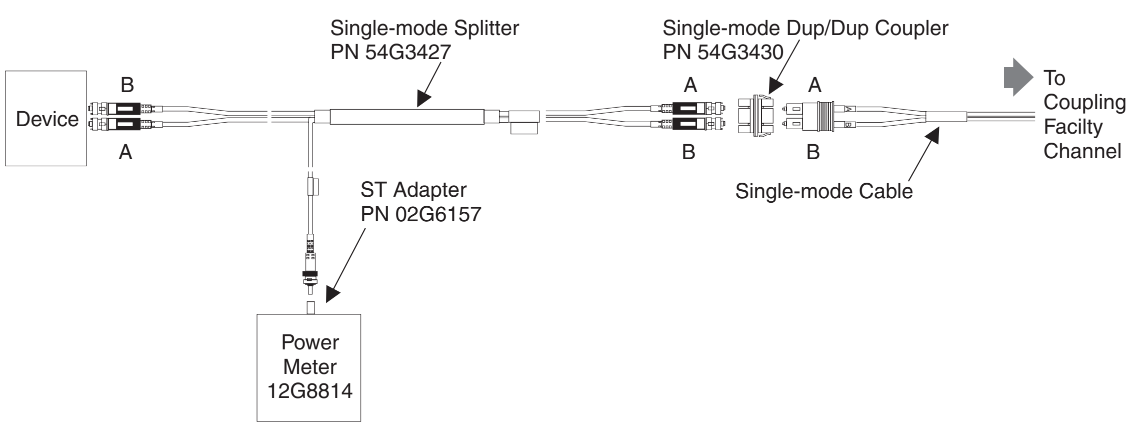


Figure C-16. Measuring Receive-In Power for a Single-Mode Coupling Facility Channel Link (ISC Legacy)

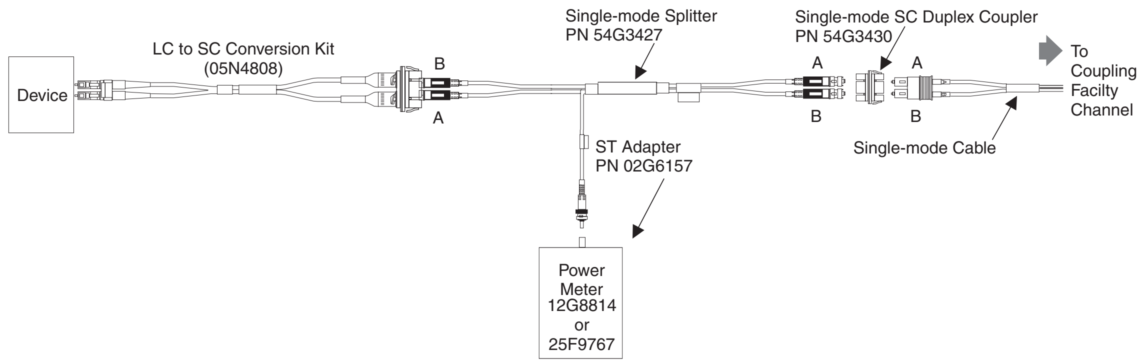


Figure C-17. Measuring Receive-In Power for an ISC3 Operating at Compatibility Mode to ISC Legacy Link (ISC3 to ISC Legacy)

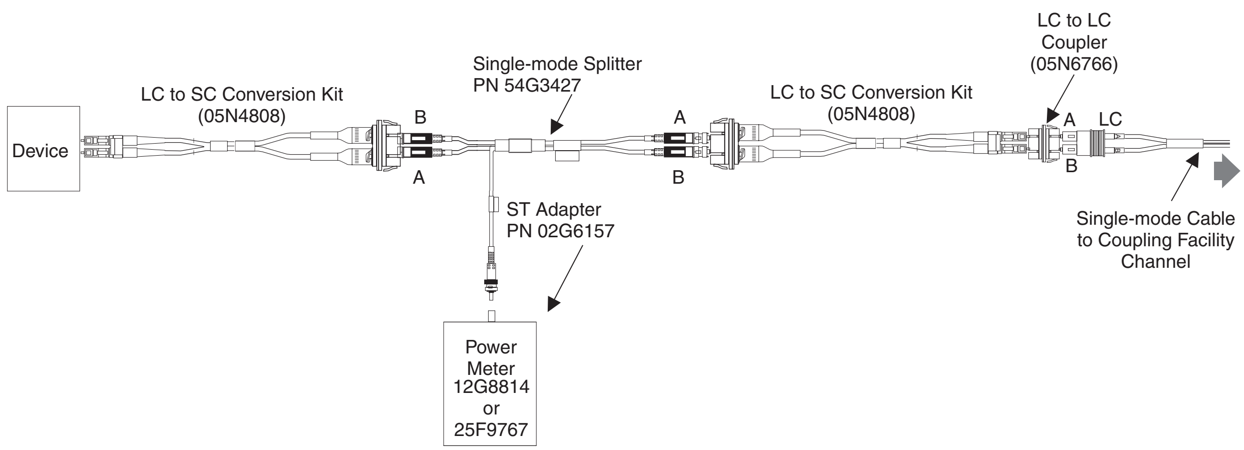


Figure C-18. Measuring Receive-In Power for an ISC3 Operating at Compatibility Mode (ISC3 to ISC3)

Measuring Transmit-Out Power for a Single-Mode Coupling Facility Channel Link

Note: The ST connector of the splitter (part number 54G3427) should remain connected to the power meter.

Assemble the test equipment (using Figure C-19 on page C-20 or Figure C-20 on page C-20) as follows:

1. Remove the splitter from the device and the link.
2. Attach the splitter connector marked “DEVICE TO BE MEASURED” to the device, and attach the unmarked splitter connector to the link using the SC duplex coupler (part number 54G3421). For ISC3, connect the LC to SC conversion kit, part number 05N4808, between the splitter and the device (see Figure C-20 on page C-20). The splitter is now positioned to measure the transmitter output power of the device.
3. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the link to re-establish transmitting, and for the power meter reading to stabilize before taking a reading. The power meter reading should be between - 13.0 dBm and - 22.0 dBm.

   Notes:

   a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. The transmitter optical power should be between -11.0 dBm and - 3.0 dBm, ± 0.5 dBm.
   b. If the level **is** within this range and the link is not operating properly, continue with the link maintenance procedure.

      If the level **is not** within this range, the device transmitter optical port could be dirty, or the transmitter could be defective. Clean the transmitter port and repeat the measurement; if the level is still out of range, the transmitter is defective; replace the card with the bad transmitter.
4. Remove the splitter from both the device and the link, and reconnect the link to the device.
5. Have you obtained the transmit and receive levels for both devices?
   - If **Yes**, return to the Fast Path step that directed you here.
   - If **No**, return to Figure C-16 on page C-17 or Figure C-17 on page C-18 and repeat the procedure for the other device.

   Note: The optical power meter reading taken with the splitter represents 10% of the true optical power in the link (10 dB), minus some loss associated with the splitter tool. The combined loss is marked on each splitter. To correct a power meter reading for the 10% power sampling, add the value given on the splitter to the power meter reading.

   This measurement procedure is accurate to within ± 0.5 dB, because of variations in the splitter’s optical connectors.

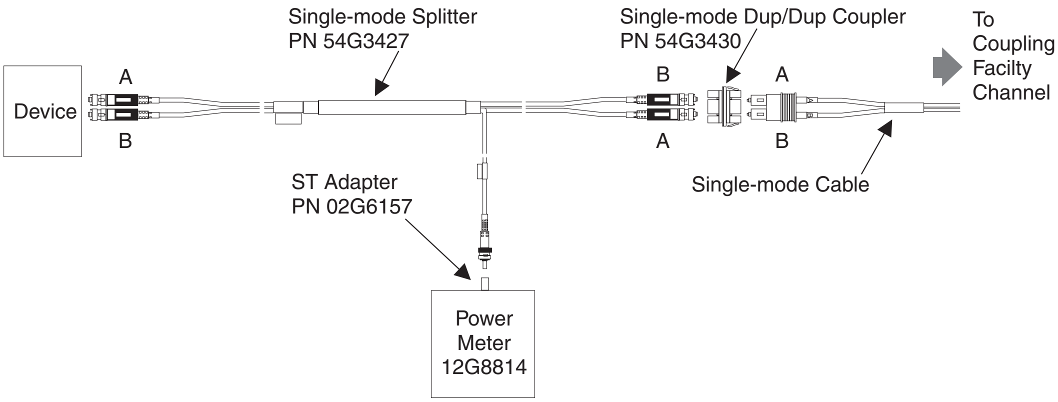


Figure C-19. Measuring Transmit-Out Power for a Single-Mode Coupling Facility Channel Link

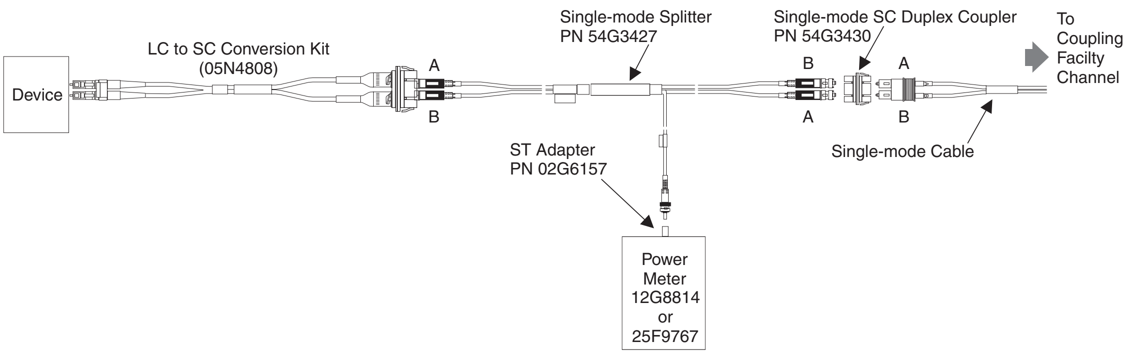


Figure C-20. Measuring Transmit-Out Power for an ISC3 Operating at Compatibility Mode to ISC Legacy Link (ISC3 to ISC Legacy)

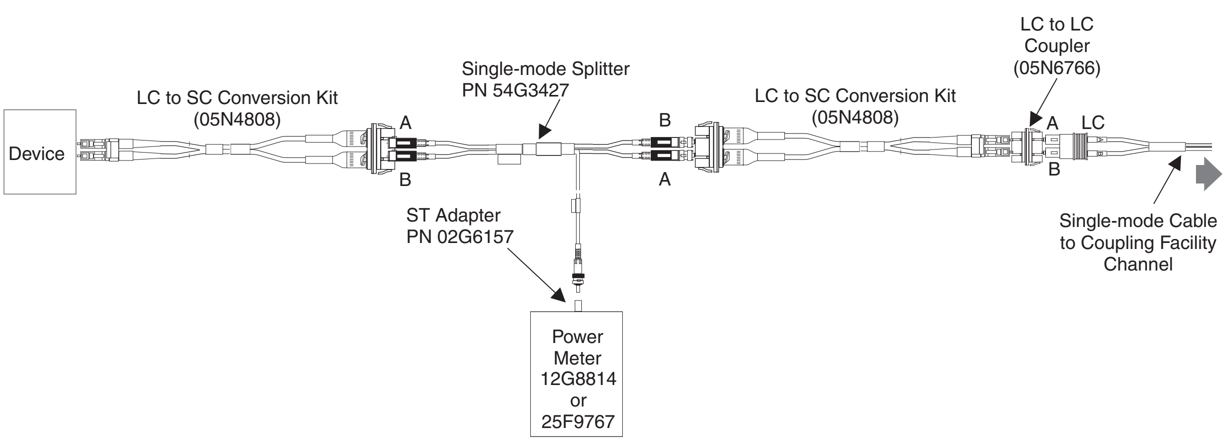


Figure C-21. Measuring Transmit-Out Power for an ISC3 Operating at Compatibility Mode for an ISC3 Compatibility Link (ISC3 to ISC3)

Isolating Link Segments Using the Splitter Tool

Coupling facility links operating at 2 Gbit/s (peer mode) do not use Open Fiber Control (OFC). Coupling facility links operating at 1 Gbit/s (compatibility mode) use the laser safety method known as Open Fiber Control (OFC). The transmitters on both ends of the link only function if there is a complete fiber link between both pairs of transmitters and receivers. If the link is opened at any point (such as

unplugging a connector or breaking a fiber), both transmitters automatically shut down, as a safety measure. The transmitters will automatically come on within 10 seconds after the link is re-established. To isolate a segment of the link, it is necessary to use a fiber optic splitter to tap off a small amount of light from an operating link.

Figure C-22 (multimode link) and Figure C-23 (single-mode link) show how to assemble the test equipment. Within 10 seconds after the link is assembled with the test equipment shown, the laser comes on and the power meter shows the light levels within the link.

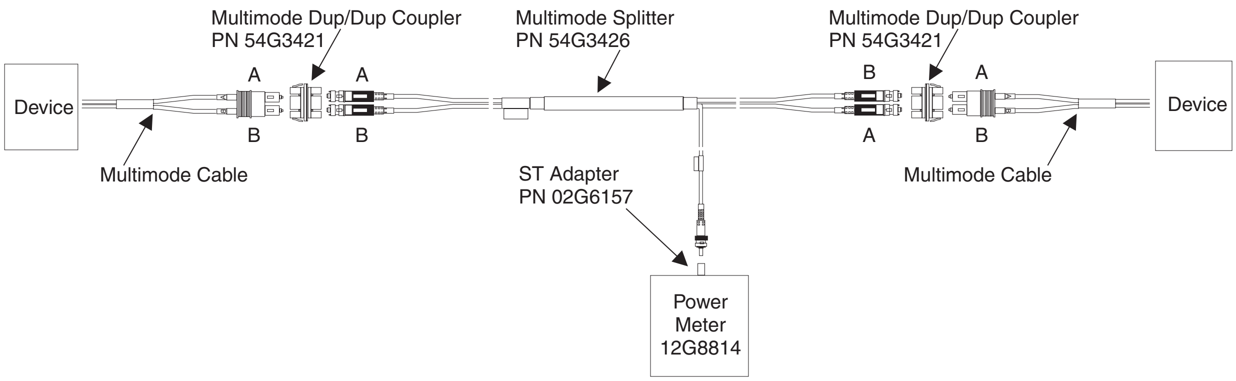


Figure C-22. Isolating a Link Segment Using the Multimode Splitter

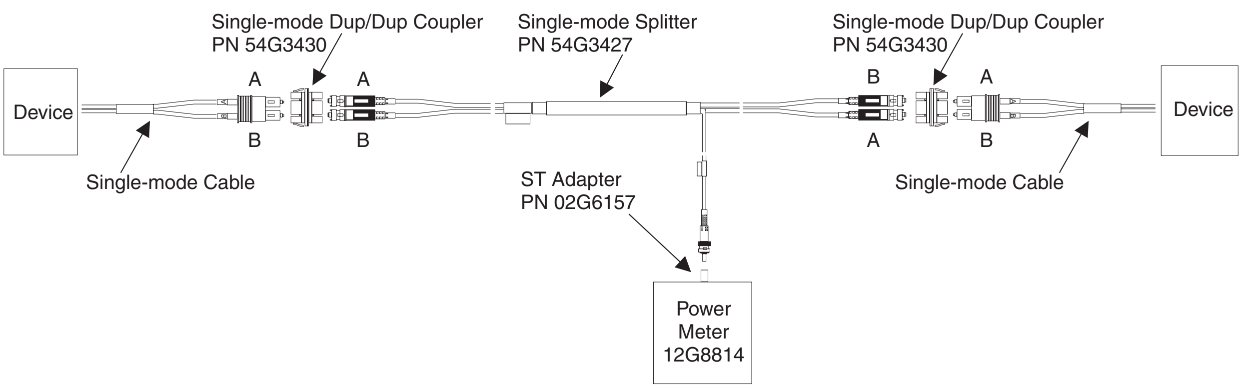


Figure C-23. Isolating a Link Segment Using the Single-Mode Splitter

Appendix D. Measurement Conversion Tables

English-to-Metric Conversion Table

English Value	Multiplied by	Equals Metric Value
Fahrenheit	(°F -32) x 0.556	Celsius
Inches	2.54	Centimeters (cm)
Inches	25.4	Millimeters (mm)
Feet	0.305	Meters (m)
Miles	1.61	Kilometers (km)
Pounds	0.45	Kilograms (kg)
Pounds	4.45	Newtons (N)

Metric-to-English Conversion Table

English Value	Multiplied by	Equals Metric Value
Celsius	(°C x 1.8) + 32	Fahrenheit
Centimeters (cm)	0.39	Inches
Millimeters (mm)	0.039	Inches
Meters (m)	3.28	Feet
Kilometers (km)	0.621	Miles
Kilograms (kg)	2.20	Pounds
Newtons (N)	0.225	Pounds

Appendix E. Work Sheets

The work sheets in this appendix may be copied and should be kept as a permanent account record.

MAP Work Sheet: Link Configuration 1

Device 1
Type ________
Serial ________
Port ________

Customer Name ____________________
Date ____________

Device 2
Type ________
Serial ________
Port ________

P0 – ____________ dBm

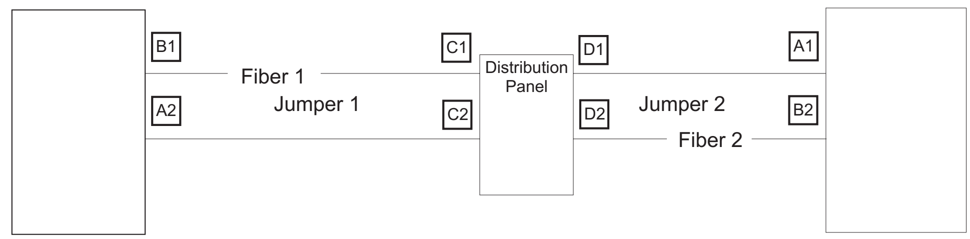
Fiber 1			Fiber 2		
P1 Reference Level	– ____________	dBm	P1 Reference Level	– ____________	dBm
L Maximum Link Loss	____________	dB	L Maximum Link Loss	____________	dB
	(-) ____________			(-) ____________	
F1 Maximum Acceptable Receive Level at A1	– ____________	dBm	F2 Maximum Acceptable Receive Level at A2	– ____________	dBm

MAP Work Sheet: Link Configuration 2

Device 1
Type ________
Serial ________
Port ________

Customer Name ____________________
Date ____________

Device 2
Type ________
Serial ________
Port ________

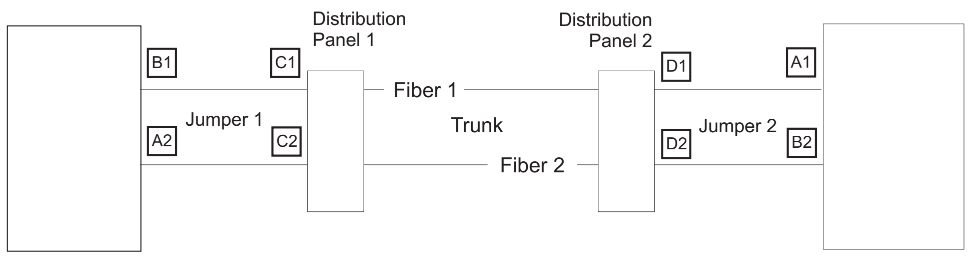


P0 – ____________ dBm

Fiber 1			Fiber 2		
P1 Reference Level	– ________	dBm	P1 Reference Level	– ________	dBm
L Maximum Link Loss	________	dB	L Maximum Link Loss	________	dB
	(-) ________			(-) ________	
F1 Maximum Acceptable Receive Level at A1	– ________	dBm	F2 Maximum Acceptable Receive Level at A2	– ________	dBm
P1 Reference Level	– ________	dBm	P1 Reference Level	– ________	dBm
L Maximum Link Loss	________	dB	L Maximum Link Loss	________	dB
	(-) ________			(-) ________	
F1 Maximum Acceptable Receive Level at A1	– ________	dBm	F2 Maximum Acceptable Receive Level at A2	– ________	dBm

MAP Work Sheet: Link Configuration 3

Device 1	Customer Name ______ Date ______	Device 2
Type ______		Type ______
Serial ______		Serial ______
Port ______		Port ______



P0 – ______ dBm

Fiber 1		Fiber 2	
P1 Reference Level	– ______ dBm	P1 Reference Level	– ______ dBm
L Maximum Link Loss	______ dB	L Maximum Link Loss	______ dB
	(-) ______		(-) ______
F1 Maximum Acceptable Receive Level at A1	– ______ dBm	F2 Maximum Acceptable Receive Level at A2	– ______ dBm
Px Reference Level	– ______ dBm	Px Reference Level	– ______ dBm
J1 Maximum Link Loss	______ dB	J2 Maximum Link Loss	______ dB
	(-) ______		(-) ______
G1 Maximum Acceptable Receive Level at C1	– ______ dBm	G2 Maximum Acceptable Receive Level at D2	– ______ dBm
Py Reference Level	– ______ dBm	Py Reference Level	– ______ dBm
J2 Maximum Link Loss	______ dB	J1 Maximum Link Loss	______ dB
	(-) ______		(-) ______
H1 Maximum Acceptable Receive Level at A1	– ______ dBm	H2 Maximum Acceptable Receive Level at A2	– ______ dBm

Fast Path Work Sheet: All Link Configurations

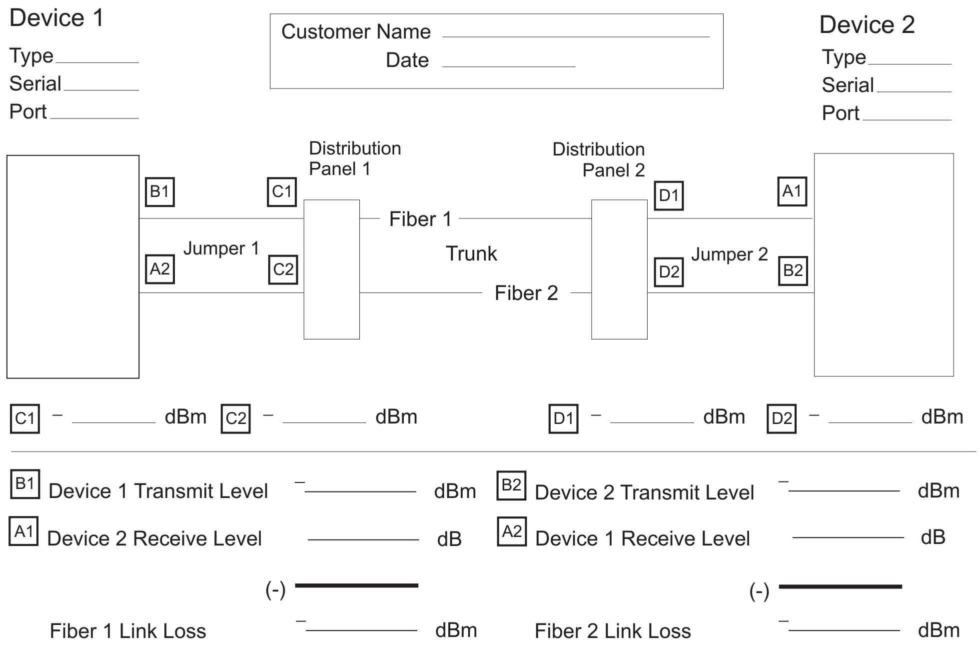


Table E-1. Maximum Link Loss When Using the Device as a Transmitter

Fiber Type	Maximum Loss	Maximum Length	Trunk Size
Multimode (1300 nm)	8 dB	2.0 km (1.24 miles)	62.5 µm
Multimode (1300 nm)	8 dB	2.0 km (1.24 miles)	50.0 µm
Multimode (1300 nm)	8 dB	3.0 km (1.86 miles)	62.5 µm
Multimode (850 nm)	8 dB	1.0 km (0.62 miles)	50.0 µm
Single-Mode (1270 - 1340 nm)	14.0 dB	20 km (12.4 miles)	9 to 10 µm
Single-Mode Coupling Facility Channel (1270 - 1355 nm)	7.0 dB	3.0 km (1.86 miles)	9 to 10 µm
Multimode (850 nm)	6.0 dB	550 meter (0.31 miles)	50 µm or 62.5 µm

Cable Administration Work Sheet

							Machine Type Ser # Port #	Product Information
							Strain Relief Used? (Y/N)	1
							Vendor	Jumper Cable Information
							Length (meter or ft)	
							Loss (dB or dB/km) and Bandwidth (Mhz •km) Specifications	
							Modified? If yes, Loss Measurement Fiber 1/Fiber 2	
							Connector Types	
							Stack Storage? (Y/N)	
							From Label Fiber 1/Fiber 2 M/T Serial	
							Path ID/Segment ID	
							To Label Fiber 1/Fiber 2	2
							Cable Manufacturer and Fiber Core Size (μm)	Trunk Information
							Installer	
							Length (km or ft)	
							Attenuation Specification (dB/km) or Loss Measurement (dB)	
							Bandwidth Specifications (Mhz• km)	
							# of Splices and Type	
							Connector Type(s) and Panel(s)	
							OTDR Print? If Yes, ID	
							From Panel ID Fiber 1/Fiber 2	
							Path ID and Segment ID	
							To Panel ID Fiber 1/Fiber 2	3
							Date Tested	Loss Measure-ment
							End-End Link Verification Loss (dB)	4
								Service Comments 5

Figure E-1. Example of a Cable Administration Work Sheet

Table E-2. Jumper Cable Power Levels

Link/Fiber Type	Cable Length in Meters (Ft.)	Level at C1 / D2	Level at C2 / D1
ESCON, ATM, FDDI, FICON, and GbE			
Multimode	4 to 73 (12 to 240)	-22.0 dBm	-29.0 dBm
Multimode	74 to 146 (243 to 479)	-22.1 dBm	-28.9 dBm
Multimode	147 to 219 (482 to 719)	-22.2 dBm	-28.8 dBm
Multimode	220 to 292 (722 to 958)	-22.4 dBm	-28.6 dBm
Multimode	293 to 365 (961 to 1198)	-22.5 dBm	-28.5 dBm
Multimode	366 to 438 (1201 to 1437)	-22.6 dBm	-28.4 dBm
Multimode	439 to 500 (1440 to 1640)	-22.7 dBm	-28.3 dBm
Coupling Facility Channels, FICON SX, GbE SX			
Multimode	7 (21)	-6.0 dBm	-15.0 dBm
Multimode	13 (33)	-6.1 dBm	-14.9 dBm
Multimode	22 (66)	-6.2 dBm	-14.8 dBm
Multimode	31 (93)	-6.3 dBm	-14.7 dBm
Multimode	46 (138)	-6.4 dBm	-14.6 dBm
Multimode	61 (183)	-6.5 dBm	-14.5 dBm
ESCON, ATM, FICON LX, GbE LX, Coupling Facility			
Single-Mode	7 (21)	-11.0 dBm	-20.0 dBm
Single-Mode	13 (33)	-11.1 dBm	-19.9 dBm
Single-Mode	22 (66)	-11.2 dBm	-19.8 dBm
Single-Mode	31 (93)	-11.3 dBm	-19.7 dBm
Single-Mode	46 (138)	-11.4 dBm	-19.6 dBm
Single-Mode	61 (183)	-11.5 dBm	-19.5 dBm
Note: ESCON channels using the FICON connector may use FICON cables with the values described above.			

Multimode Calculated Link Loss Work Sheet

A. Calculating the Multimode Component Mean Loss

Connection loss multiplied by the number of connections in the link:

________- µm-to-________- µm connection:	________	dB	x	________		=	________	dB
________- µm-to-________- µm connection:	________	dB	x	________		=	________	dB
Splice loss multiplied by total number of splices in the link:	________	dB	x	________		=	________	dB
Jumper cable loss multiplied by the combined length of the jumper cables:	________	dB/km	x	________	km	=	________	dB
Trunk loss per kilometer multiplied by the total trunk length (in km):	________	dB/km	x	________	km	=	________	dB
							(+) ________	
(For FDDI only, add 2.0 dB system loss to this value.)				**Total Component Mean Loss**			________	dB

B. Calculating the Multimode Component Variance Loss

Connection variance multiplied by the number of connections in the link:

________- µm-to-________- µm	________	dB^2	x	________		=	________	dB^2
________- µm-to-________- µm connection:	________	dB^2	x	________		=	________	dB^2
Splice variance multiplied by total number of splices in the link:	________	dB^2	x	________		=	________	dB^2
Jumper cable loss multiplied by the combined length of the jumper cables:	________	dB/km	x	________	km	=	________	dB^2
							(+) ________	
(For FDDI only, add 0.04 dB^2 system loss to this value.)				**Total Component Variance Loss**			________	dB^2

C. Calculating the Total Multimode Link Loss

Total component mean loss:				=	________	dB
Square root of total component variance loss multiplied by 3:	$\sqrt{\_\_\_\_\_\_\ dB^2}$	=	________ dB x 3	=	________	dB
High order mode loss (ESCON only):				=	________	dB
50.0-µm trunk = 1.5 dB					(+) ________	
62.5-µm trunk = 1.0 dB						
Note: Maximum allowable link loss for different type links is given in Table A-1 on page A-2.			**Calculated Link Loss**		________	dB

Single-Mode Calculated Link Loss Work Sheet

A. Calculating the Single-Mode Component Mean Loss

Connection loss multiplied by the number of connections in the link:	________ dB	x	________	=	________ dB
Splice loss multiplied by total number of splices in the link:	________ dB	x	________	=	________ dB
Jumper cable loss multiplied by the combined length of the jumper cables:	________ dB/km	x	________ km	=	________ dB
Trunk loss per kilometer multiplied by the total trunk length (in km):	________ dB/km	x	________ km	=	________ dB
					(+) __________
			Total Component Mean Loss		________ dB

B. Calculating the Single-Mode Component Variance Loss

Connection variance multiplied by the number of connections in the link:	________ dB^2	x	________	=	________ dB^2
Splice variance multiplied by total number of splices in the link:	________ dB^2	x	________	=	________ dB^2
					(+) __________
			Total Component Variance Loss		________ dB^2

C. Calculating the Total Single-Mode Link Loss

Total component mean loss:				=	________ dB
Square root of total component variance loss multiplied by 3:	$\sqrt{\_\_\_\_\_ + 0.05\ dB^2}$	=	________ dB x 3	=	________ dB
Jumper assembly loss plus excess connector loss:				=	0.50 dB
					(+) __________
			Calculated Link Loss		________ dB

Calculating the Loss in a Multimode Link

This chapter describes how to calculate the maximum allowable loss for an fiber optic link that uses multimode components. It shows an example of a multimode ESCON link and includes a completed work sheet that uses values based on the link example. The same procedures may be used to calculate the link loss for a coupling facility channel, ATM, FDDI, FICON, or GbE link. Note that the jumper and trunk losses for a multimode coupling facility channel link will be larger than for a multimode ESCON link of the same length. This is because all ESCON, ATM, FDDI, FICON, and GbE links operate at 1300 nm wavelength, while multimode coupling facility channel links operate at 780 nm, and the fiber loss is greater at 780 nm. Be sure to use the fiber loss corresponding to the proper wavelength for multimode links; refer to the ESCON and coupling facility channel link physical layer documents for more information.

Each link has a loss (attenuation) whose value depends on the loss induced by each cable, connector, and splice. This value, when calculated, cannot be greater than the maximum link loss (see Table A-1 on page A-3).

Use the following explanation and refer to the configuration example (Figure E-2 on page E-12) and the work sheet example (Table E-3 on page E-13). Although actual values should be used if possible, this example uses the typical loss values shown in Table A-2 on page A-6.

Completing a Loss Work Sheet for a Multimode Link

Use Section A of the Link Loss Work Sheet to calculate the total component mean loss, Section B to calculate the component variance loss, and Section C to calculate the total link loss.

Dispersion

Dispersion in an optical system is the spreading of information pulses over the fiber with distance. The maximum distance at which the incoming signal pulses are still separated well enough for correct detection is the point at which the link becomes dispersion limited. Fibers are available from vendors in different sizes and characteristics. Dispersion is not a factor for 62.5/125-µm fiber with a modal bandwidth of 500 MHz•km for distances up to 2 km. Dispersion can become a consideration for other fiber sizes as distances approach the FDDI 2-km maximum. Most FDDI products have been designed to meet the FDDI maximum specification for 62.5/125-µm fiber. For greater distances or for fiber that does not meet the FDDI specification, contact the device manufacturer.

Dispersion is not a limiting factor for ESCON, GbE, ATM, or FICON links.

Link Limitations

FDDI Multimode Link

The following link conditions should be met, on a FDDI link, when using the work sheets provided:

- If 50-µm jumper cables are used in the design, all link segments of the design should use only 50-µm fiber.
- A connection from 100- to 50-µm fiber is not supported, because of excessive attenuation.
- A connection from 62.5- to either 50- or 100-µm fiber and subsequently back to 62.5-µm fiber should be made only once within the link.

- Splices should be made only to fibers with the same core diameters.

ESCON, GbE, ATM, or FICON Link

An ESCON, GbE, ATM, or FICON link should use either singlemode or multimode fiber throughout and not convert from one fiber type to another. Although the ANSI FICON does not include the use of long wavelength (1300 nm) lasers in multimode fiber, IBM will support 50.0 µm and 62.5 µm multimode fiber as well as 4.0 µm singlemode fiber as specified in Refer to the *Fiber Channel Connection (FICON I/O Interface Physical Layer*, SA24-7172.

Loss Calculation

Each link has a specific calculated loss value that depends on the loss induced by each cable, connector, and splice. This calculated value combined with other parameters cannot be greater than the maximum link loss. Maximum link loss specifications are given in Table A-1 on page A-3.

Section A: Calculating the Multimode Component Mean Loss

The fiber cable manufacturer should provide either the component mean (average) loss or worst-case specification data. If the mean value is not available, use the worst-case specification data to complete Section A. If the manufacturer's data is not available, use the typical component loss values from Table A-2 on page A-6.

Connections: Multiply the average connection loss value by the total number of connections in the link. Connections to coupling facility channel-capable, FICON-capable, or ESCON-capable devices are included in the device specification and should **not** be included in the connection calculation.

Note: A link consisting of one IBM duplex-to-duplex jumper cable is considered to have no connections when calculating the link loss.

Splice Loss: Multiply the splice loss value by the total number of link splices. If the link has both mechanical and fusion splices, calculate the losses separately, then enter the total on the work sheet.

Jumper Cable Loss: Multiply the combined length of the jumper cables in kilometers by the jumper cable loss per kilometer.

Trunk Cable Loss: Multiply the total length of the trunk cable in kilometers by the cable loss per kilometer.

Section B: Calculating the Multimode Component Variance Loss

The fiber cable manufacturer should provide the values used to determine variance loss. This loss, attributable to manufacturing tolerances or installation methods (or both), is induced by connections and splices.

- If the manufacturer's data is not available, use the typical component loss values from Table A-2 on page A-6.
- If the manufacturer has provided only worst-case specification data, it includes the variance loss. Enter a value of zero on the work sheet for the Total Component Variance Loss.
- If the manufacturer provides a standard deviation (σ) value, use the square of this value to determine the component variance loss. For example, if σ equals 0.24, then enter a value of 0.06 (0.24 squared) on the worksheet for the Total Component Variance Loss.

Connections: Multiply the connection variance value by the total number of connections in the link. Connections to ESCON-capable devices are included in the device specification and **should not** be included in the connection calculation.

Splice Variance: Multiply the splice variance value by the total number of splices in the link.

- For FDDI links only, include the system variance of 0.04 dB^2.

Section C: Calculating the Total Multimode Link Loss

The total calculated link loss includes the following values:

- All calculated component mean losses.
- Three times the square root of the sum of the calculated component variances.
- The higher-order mode loss. This loss, induced by the connectors and the first few hundred meters of each link, is assigned a constant value, depending on the trunk fiber size. This loss should only be included for an ESCON link.
  - For 50.0-µm trunk fiber, use 1.5 dB.
  - For 62.5-µm trunk fiber, use 1.0 dB.
- The FDDI system loss, for FDDI links only; this value is 2.0 dB and includes extinction ratio penalty, higher order mode losses and retiming penalty for an FDDI link.

Loss Calculation Example for a Multimode ESCON Link

Figure E-2 shows a link example consisting of:

- Jumper Cable 1 (IBM duplex-to-duplex, multimode, 13 meters).
- Jumper Cable 2 (IBM duplex-to-duplex, multimode, 77 meters)

  (combined jumper cable length = 90 meters or 0.09 km).
- 1.5 km of 50-μm trunk cable (bandwidth = 800 MHz•km).
- One 62.5-μm-to-50.0-μm physical-contact connection (in each fiber).
- One 50.0-μm-to-62.5-μm physical-contact connection (in each fiber).
- Six 50-μm mechanical splices (in each fiber).
- Trunk cable connectors are ST (physical contact).

Note: The example of a completed Calculated Link Loss Work Sheet (Table E-3 on page E-13) uses Table A-2 on page A-6, which lists typical values for currently used components. Use Table A-2 on page A-6**only** if the manufacturer's specifications are not available.

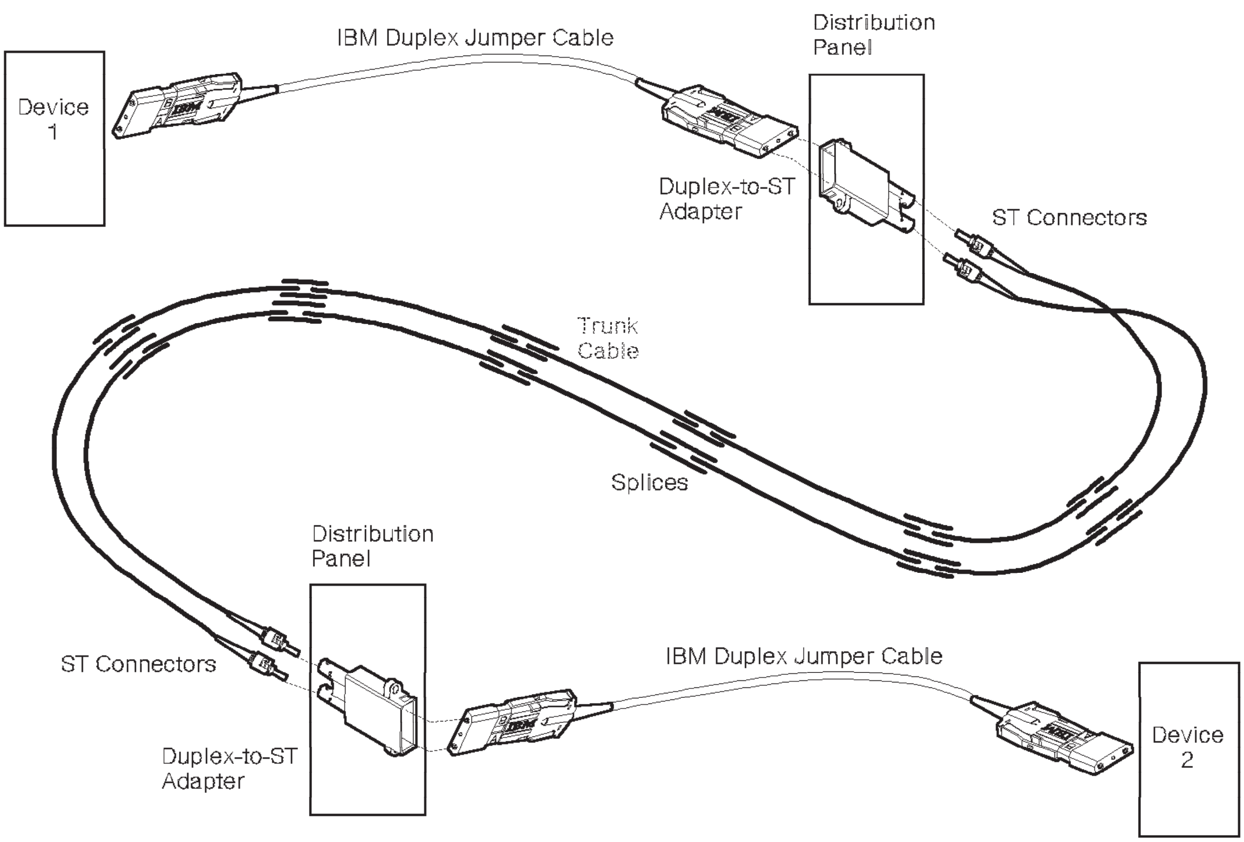


Figure E-2. Example of a Multimode ESCON Link

Table E-3. Example of a Completed Calculated Link Loss Work Sheet for a Multimode Link. This example was completed for an ESCON link.

A. Calculating the Multimode Component Mean Loss

Connection loss multiplied by the number of connections in the link:					
__62.5___- µm-to-__50.0__- µm connection:	__2.10__ dB	x	___1___	=	__2.10__ dB
__50.0___- µm-to-__62.5__- µm connection:	___0____ dB	x	___1____	=	___0____ dB
________- µm-to-________- µm connection:	________ dB	x	_________	=	_________ dB
Splice loss multiplied by total number of splices in the link:	__0.15__ dB	x	___6____	=	__0.90__ dB
Jumper cable loss multiplied by the combined length of the jumper cables:	__1.75__ dB/km	x	__0.09__ km	=	__0.16__ dB
Trunk loss per kilometer multiplied by the total trunk length (in km):	__0.90__ dB/km	x	__1.5___ km	=	__1.35__ dB
					(+) __________
(For FDDI only, add 2.0 dB system loss to this value.)			**Total Component Mean Loss**		__4.51__ dB

B. Calculating the Multimode Component Variance Loss

Connection variance multiplied by the number of connections in the link:					
__62.5__- µm-to-__50.0__- µm	__0.12__ dB^2	x	____1___	=	__0.12__ dB^2
__50.0__- µm-to-__62.5__- µm connection:	__0.01__ dB^2	x	____1___	=	__0.01__ dB^2
________- µm-to-_______- µm connection:	_______ dB^2	x	_________	=	_______ dB^2
Splice variance multiplied by total number of splices in the link:	__0.01__ dB^2	x	____6___	=	__0.06__ dB^2
					(+) __________
(For FDDI only, add 0.04 dB^2 system loss to this value.)			**Total Component Variance Loss**		__0.19__ dB^2

C. Calculating the Total Multimode Link Loss

Total component mean loss:				=	__4.51__ dB
Square root of total component variance loss multiplied by 3:	$\sqrt{\_0.19\_\ dB^2}$	=	__0.44__ dB x 3	=	__1.32__ dB
High order mode loss (ESCON only): 50.0-µm trunk = 1.5 dB 62.5-µm trunk = 1.0 dB				=	___1.5__ dB (+) __________
Note: Maximum allowable link loss for different type links is given in Table A-1 on page A-2.			**Calculated Link Loss**		__7.3___ dB

Loss Calculation for an FDDI Multimode Link

Figure E-3 shows a link example consisting of:

- Jumper Cable 1: IBM FDDI-to-IBM FDDI, physical contact, 62.5 µm, 12 m.
- Jumper Cable 2: ST-to-ST, physical contact, 62.5 µm, 12 m.
- Jumper Cable 3: IBM FDDI-to-IBM FDDI, physical contact, 62.5 µm, 12 m.
- 2.0 km of 62.5-µm trunk cable
  – The first trunk segment is 100 m.
  – The second trunk segment is 1.9 km.
- Seven 62.5 µm mechanical splices
  – Two splices are included to allow for possible future repair.
  – Five splices are already in the fiber.
- Trunk cable connectors are ST (physical contact).

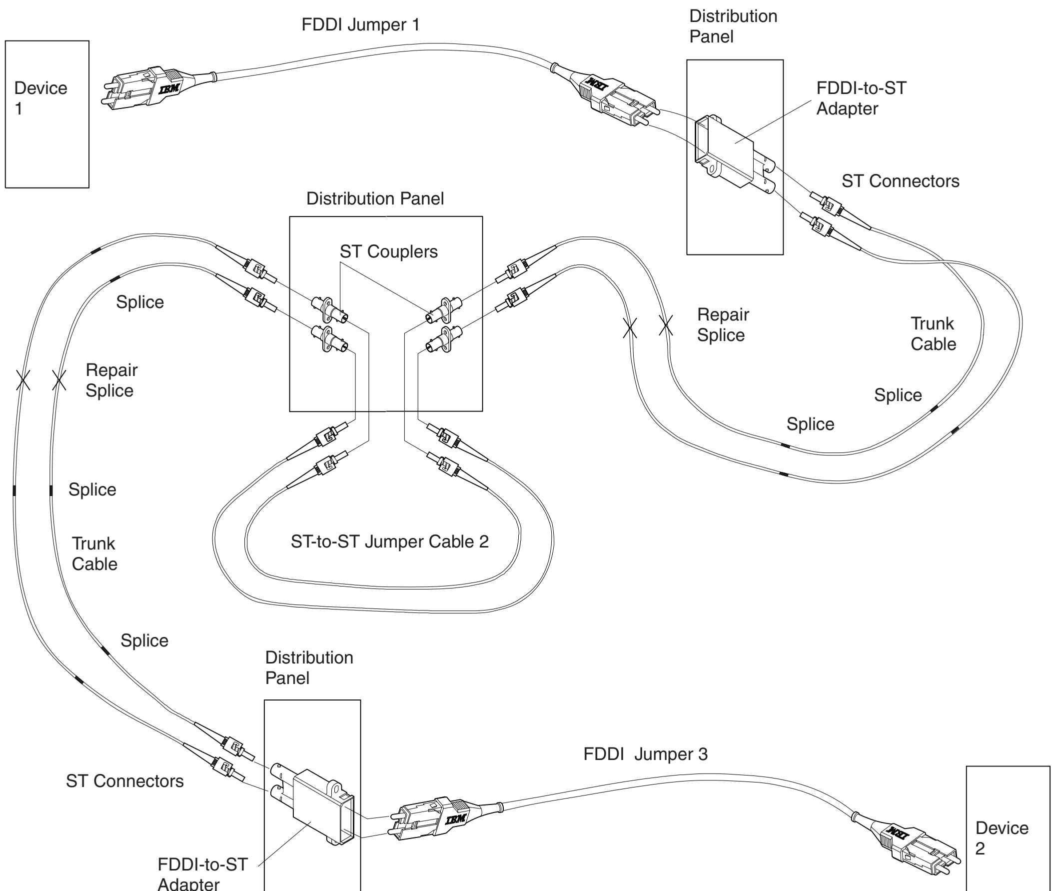


Figure E-3. Typical FDDI Link and Components

Note: The example of a completed Calculated Link Loss Work Sheet (Table E-4 on page E-15) uses Table A-2 on page A-6, which lists typical values for currently used components.

Table E-4. Example of a Completed Calculated Link Loss Work Sheet for an FDDI Link

A. Calculating the Multimode Component Mean Loss

Connection loss multiplied by the number of connections in the link:					
__**62.5**___- µm-to-__**62.5**__- µm connection:	__**0.4**___ dB	x	___**4**___	=	__**1.6**___ dB
_________- µm-to-_______- µm connection:	________ dB	x	_________	=	________ dB
Splice loss multiplied by total number of splices in the link:	__**0.15**__ dB	x	___**7**____	=	__**1.05**__ dB
Jumper cable loss multiplied by the combined length of the jumper cables:	__**1.75**__ dB/km	x	__**0.036**__ km	=	__**0.06**__ dB
Trunk loss per kilometer multiplied by the total trunk length (in km):	__**1.0**___ dB/km	x	__**2.0**___ km	=	__**2.0**___ dB
					(+) __________
(For FDDI only, add 2.0 dB system loss to this value.)			**Total Component Mean Loss**		__**4.71**__ dB

B. Calculating the Multimode Component Variance Loss

Connection variance multiplied by the number of connections in the link:					
__**62.5**__- µm-to-__**50.0**__- µm	__**0.02**__ dB^2	x	____**4**___	=	__**0.08**__ dB^2
________- µm-to-_______- µm connection:	________ dB^2	x	_________	=	_______ dB^2
Splice variance multiplied by total number of splices in the link:	__**0.01**__ dB^2	x	____**7**___	=	__**0.07**__ dB^2
					(+) __________
(For FDDI only, add 0.04 dB^2 system loss to this value.)			**Total Component Variance Loss**		__**0.15**__ dB^2

C. Calculating the Total FDDI Multimode Link Loss

System loss (2.0 dB):				=	2.0 dB^2
Total component mean loss:				=	__**4.71**__ dB
Square root of total component variance loss plus system variance loss (0.04 dB) multiplied by 3:	$\sqrt{\underline{0.15+0.04}\ dB^2}$	=	__**0.436**__ dB x 3	=	__**1.31**__ dB
					(+) __________
Note: Maximum allowable link loss for different type links is given in Table A-1 on page A-2.			**Calculated Link Loss**		__**8.02**__ dB

Calculating the Loss in a Single-Mode Link

This chapter describes how to calculate the maximum allowable loss for an ESCON link that uses single-mode components. It shows an example of a single-mode ESCON link and includes a completed work sheet that uses values based on the link example. The same procedure can be used to calculate the loss for a single-mode coupling facility channel link.

Each link has a loss (attenuation) whose value depends on the loss induced by each cable, connector, and splice. This value, when calculated, cannot be greater than the maximum link loss (see Table A-1 on page A-3).

Use the following explanation and refer to the configuration example (Table E-4 on page E-15) and the work sheet example (Table E-5 on page E-19). Although actual values should be used if possible, this example uses the typical loss values shown in Table A-2 on page A-6.

Completing a Loss Work Sheet for a Single-Mode Link

Use Section A of the Link Loss Work Sheet to calculate the total component mean loss, Section B to calculate the component variance loss, and Section C to calculate the total link loss.

Section A: Calculating the Single-Mode Component Mean Loss

The fiber cable manufacturer should provide either the component mean (average) loss or worst-case specification data. If the mean value is not available, use the worst-case specification data to complete Section A. If the manufacturer's data is not available, use the typical component loss values from Table A-2 on page A-6.

Connections: Multiply the average connection loss value by the total number of connections in the link. Connections to coupling facility channel-capable or ESCON-capable devices are included in the device specification and **should not** be included in the connection calculation.

Notes:

1. A link consisting of one IBM duplex-to-duplex jumper cable is considered to have no connections when calculating the link loss.
2. The ESCON XDF Adapter kit does **not** add connection loss to the link.

Splice Loss: Multiply the splice loss value by the total number of link splices. If the link has both mechanical and fusion splices, calculate the losses separately, then enter the total on the work sheet.

Note: Because a single-mode link can be up to 20 kilometers (12.4 miles) and fiber cable is available in reels of from 1 to 7 kilometers (0.62 to 4.35 miles), single-mode trunk cable could require "reel-to-reel" splicing. If this loss is included in the trunk cable loss, **do not** include it in the splice loss calculation. If not certain about whether to include this value, contact your marketing representative.

Jumper Cable Loss: Multiply the combined length of the jumper cables in kilometers by the jumper cable loss per kilometer.

Trunk Cable Loss: Multiply the total length of the trunk cable in kilometers by the cable loss per kilometer.

Section B: Calculating the Single-Mode Component Variance Loss

The fiber cable manufacturer should provide the values used to determine variance loss. This loss, attributable to manufacturing tolerances or installation methods (or both), is induced by connections and splices.

- If the manufacturer's data is not available, use the typical component variance loss values from Table A-2 on page A-6.
- If the manufacturer has provided only worst-case specification data, it includes the variance loss. Enter a value of zero on the work sheet for the Total Component Variance Loss.
- If the manufacturer provides a standard deviation (σ) value, use the square of this value to determine the component variance loss. For example, if σ equals 0.24, then enter a value of 0.06 (0.24 squared) on the worksheet for the Total Component Variance Loss.

Connections: Multiply the connection variance value by the total number of connections in the link. Connections to coupling facility channel-capable or ESCON-capable devices are included in the device specification and s**hould not** be included in the connection calculation.

Note: The ESCON XDF Adapter kit does **not** add connection loss to the link.

Splice Variance: Multiply the splice variance value by the total number of splices in the link.

Section C: Calculating the Total Single-Mode Link Loss

The total calculated link loss includes the following values:

- All calculated component mean losses.
- Three times the square root of the sum of the calculated component variances plus the jumper assembly variance loss (0.05 dB)
- The jumper assembly loss and the excess connector loss. For a 9-µm trunk cable, these values are:
  - Jumper assembly loss = 0.3 dB
  - Excess connector loss = 0.2 dB.

Loss Calculation Example for a Single-Mode Link

Figure E-4 shows a link example consisting of:

- Jumper Cable 1 (IBM duplex-to-duplex, single-mode, 92 meters).
- Jumper Cable 2 (IBM duplex-to-duplex, single-mode, 122 meters) (combined jumper cable length = 214 meters or 0.21 km).
- 19.76 km of 9-µm trunk cable.
- Two physical-contact ST connections (in each fiber).
- Two mechanical splices (in each fiber).

Note: The example of a completed Calculated Link Loss Work Sheet (Table E-5 on page E-19) uses Table A-2 on page A-6, which lists typical values for currently used components. Use Table A-2 on page A-6 **only** if the manufacturer's specifications are not available.

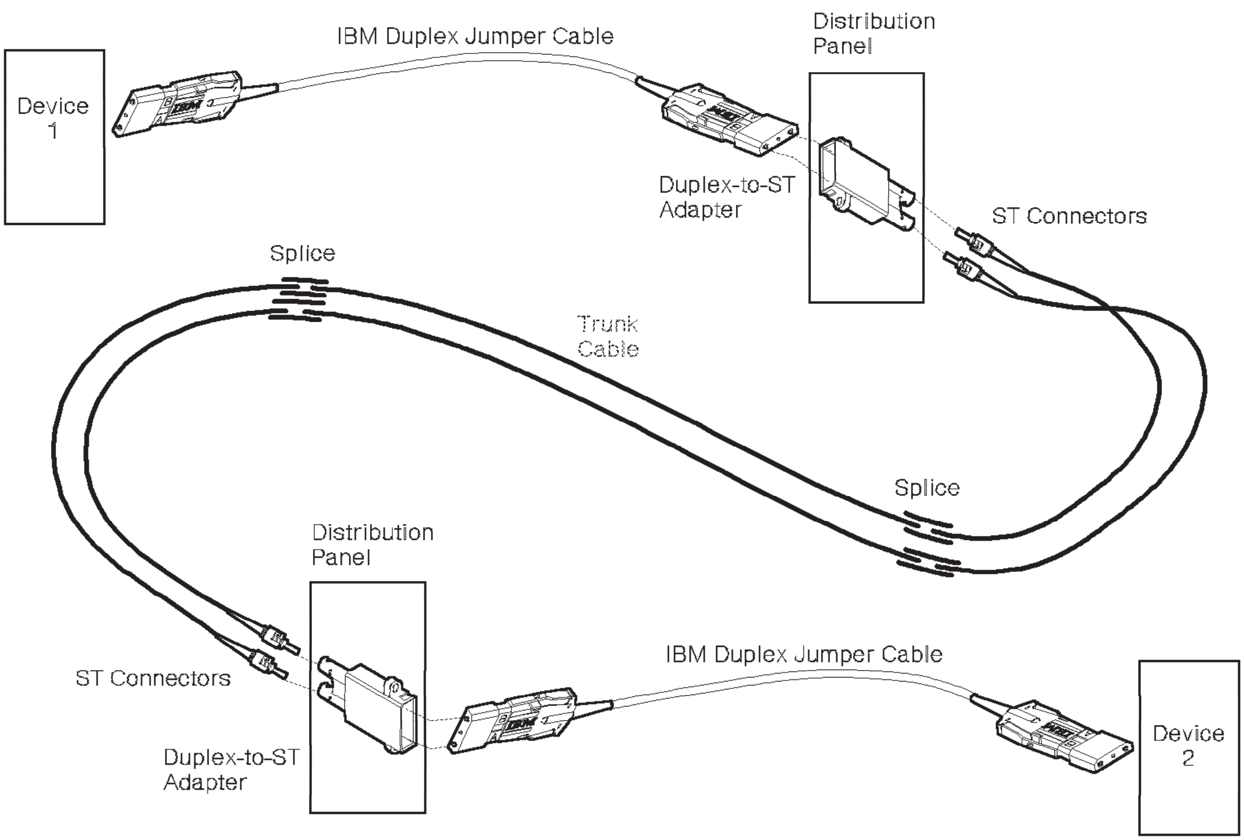


Figure E-4. Example of a Single-Mode ESCON Link

Table E-5. Example of a Completed Calculated Link Loss Work Sheet for a Single-Mode Link. This example was completed for an ESCON link.

A. Calculating the Single-Mode Component Mean Loss

Connection loss multiplied by the number of connections in the link:	__**0.35**__ dB	x	___**2**___	=	__**0.706**__ dB
Splice loss multiplied by total number of splices in the link:	__**0.15**__ dB	x	___**2**____	=	__**0.30**___ dB
Jumper cable loss multiplied by the combined length of the jumper cables:	__**0.8**___ dB/km	x	__**0.21**__ km	=	__**0.17**__ dB
Trunk loss per kilometer multiplied by the total trunk length (in km):	__**0.5**___ dB/km	x	__**19.76**__ km	=	__**9.88**__ dB
					(+) __________
			Total Component Mean Loss		__**11.05**__ dB

B. Calculating the Single-Mode Component Variance Loss

Connection variance multiplied by the number of connections in the link:	__**0.06**__	x	____**2**___	=	__**0.12**__ dB^2
Splice variance multiplied by total number of splices in the link:	__**0.01**__ dB^2	x	____**2**___	=	__**0.02**__ dB^2
					(+) __________
			Total Component Variance Loss		__**0.14**__ dB^2

C. Calculating the Total Single-Mode Link Loss

Total component mean loss:				=	__**11.05**__ dB
Square root of total component variance loss plus system variance loss (0.04 dB) multiplied by 3:	$\sqrt{\underline{\textbf{0.14}} + 0.05\ dB^2}$	=	__**0.436**__ dB x 3	=	__**1.31**__ dB
Jumper assembly loss plus excess connector loss:				=	0.50 dB
					(+) __________
.			**Calculated Link Loss**		__**12.86**__ dB

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